

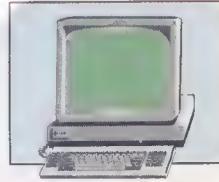
PC UPGRADE

BUILDING YOUR OWN PERSONAL COMPUTER

THE GUIDE FOR ASSEMBLING & EXPANDING A PC



Building a PC from XT's to '486's



Parts Buying Guide
How to Assemble

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- Install and Use Hard Drives
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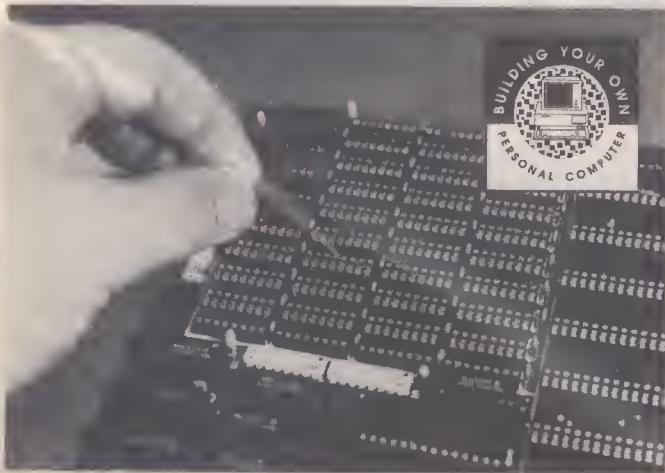
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You Can Do It Yourself



Why build an IBM compatible computer? Why indeed! Check out these advantages:

- Save 10% to 40% over a "real" IBM PC, or similarly equipped compatible.
- Add only those features you want; you don't pay extra for features you don't use.
- Assured compatibility with IBM software and hardware.
- Avoid the high cost of obsolescence because you can cost-effectively exchange parts of the computer to keep it up to date.
- Learn the what's and how's of computers, making you a near-expert. You can better diagnose problems because you really know "what's under the hood."
- It's fun.

Build Your Own

Building your own PC compatible computer (which includes XT, AT, 80386-, and 80486-based machines) doesn't require special tools or know-how. You just buy the individual pieces — called components, parts, or subsystems — and hook them up. Because most components are designed after the IBM product (or have been standardized by the personal computer industry), they are interchangeable, even those among different manufacturers. The parts come pre-wired, assembled, and complete. There is no soldering involved; all you need is a screwdriver and a small pair of pliers.

How long does it take to assemble a clone computer? Even if you take your time, and check your work twice (which is a good idea anyway), you can get through the job in just one or two hours.

Instructions You Can Understand

While building your own clone is no real chore, there are some frustrating and potentially dangerous and costly pitfalls. A few suppliers of PC clone parts provide instruction manuals to help you in assembling your computer, but most of the books are hard to follow. The majority are poorly translated from Taiwanese, Japanese, or Chinese. Trying to follow them can be downright annoying. Sure, the manuals are good for laughs once in a while, but you'll be deadly serious when you can't figure out which cable goes to which connector.

Building Your Own PC is a special issue of Computer Buyer's Guide & Handbook, one of the oldest computer magazines published. Inside this magazine is all the information you'll need on how to assemble, test, and use a PC clone. You'll find step-by-step details on putting everything together, troubleshooting charts in case things don't go exactly right, and supplementary information — like a full set of schematics and connector pinout diagrams — that will be useful now or in the future.

This special issue has been specifically written to help first-timers as well as advanced computer users make the best of their clone investment. You are guided every step of the way and technical jargon is kept to a minimum.

What You'll Learn:

- The differences between XT, AT, 80386-, and 80486-based computers.
- How to install memory chips in the motherboard.
- How to set the jumpers and switches on the motherboard to accurately reflect the system parameters of your computer.
- How to attach disk drives to computer, and how to alter the switches and jumpers on the drives.
- How to effectively test the computer once it's built to make sure everything is working properly.
- How to diagnose and fix problems, without special test equipment.
- How to shop wisely for the best clone parts deal.
- How to examine the components before you buy, to make sure you're not getting defective parts.
- How to use a turbo motherboard.

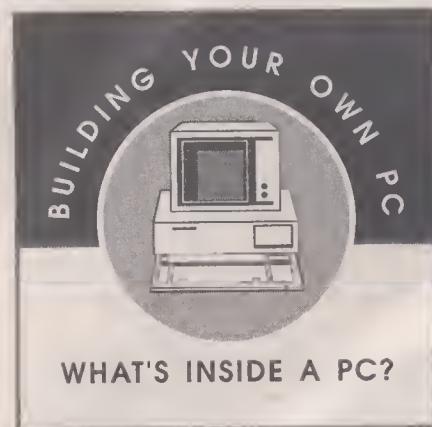
Please note that when this guide refers to the generic PC it means XT, AT, 80386 or 80486 system unless otherwise specified.

Enough talk. Time to begin. Get on your work overalls, grab your screwdriver, and let's begin!

Gordon McComb
Editor

PC Basics

An introduction to personal computer technology for do-it-yourselfers.



The Personal Computer, or PC, was introduced by IBM in 1981. Besides the all-important initials "IBM," the PC became an almost instant success because of its engineering. The PC provided, in one fairly small box, an extremely powerful and expandable computer. Through the years, IBM and other companies have improved on the design of the PC — they've made it faster, more powerful, and capable of performing just about as well as a mini-computer costing 10 to 20 times as much.

The PC spawned a good number of imitators, who originally designed and built complete computer systems to compete with the IBM product. These "clones" included the Compaq (still going strong), the Eagle PC, the Seequa Chameleon, the Corona PC, and a long list of dozens of others. Today, few of these computers exist; they have been almost completely supplanted by the "generic" clone.

The generic clone is an IBM PC compatible computer modeled inside and out almost directly from the original. Generic clones look and act almost indistinguishably from the IBM product. Some of these clones come already assembled, but a growing number are in kit or component form. The circuit boards, power supplies, disk drives, and other parts are already soldered and wired for you; you complete the assembly process by connecting the pieces together. This is the build-your-own clone, a computer that is every bit as useful and compatible as any other generic machine available.

All PC compatible clones, whether you build them yourself or not, consist of a variety of similar components, connected the same way (the original PC serves as a blueprint). This section intro-

duces you to the technology involved in getting the computer to do its work. Besides the basics, you'll also learn what options you can add to the rudimentary computer to provide more power, increased speed, and greater performance.

If you are already well versed in PC technology, skip this section and go on to the next. Or, if you like, skim through the following pages as a kind of "refresher course."

XT, AT, '386, or '486?

IBM's early flagship models were the XT and AT (the XT is nearly identical to the original IBM PC, but came with a hard drive, which is now considered standard equipment on personal computers). IBM no longer makes either of these machines, but they are still going strong in the generic clone market.

The XT is an excellent starter or student system, and its low cost makes it ideal for those on a budget. However, the XT has been greatly surpassed in speed and flexibility by the AT class computer, which boasts a more powerful central brain (the Intel 80286 microprocessor) and more efficient data processing capabilities. As a do-it-yourself computer, you will probably opt for the AT style of computer, which costs a few hundred dollars more than the basic XT system.

Conveniently, the AT can accept almost all of the software and hardware designed for the XT, but operates faster.

Like the build-it-yourself parts for the XT, you can purchase kits and components to make your own AT compatible.

After the AT, IBM drastically changed the design of their personal computers and introduced the PS/2 line, which the company currently sells. Some of the PS/2 computers were mere re-workings of the old AT, with a few refinements here and there. However, several of the other models used a more sophisticated microprocessor brain (detailed more fully below) called the Intel 80386. These offered far greater computing capabilities over the AT, and made the original XT look like a Tinker Toy.

Though IBM changed the basic design of their computers, the compatibles market didn't follow suit. Instead, they stuck with the original IBM design of the AT and refitted it so it could accept the faster 80386 microprocessor. IBM's PS/2 computers use what is known as Micro Channel Architecture (or MCA) expansion slots (expansion slots allow you to add additional circuit boards to enhance the operation of the computer). MCA slots are entirely different from those found in the XT or AT, so the PS/2 computers require their own special kinds of expansion boards.

The clone computers, on the other hand, use what's now universally called the Industry Standard Architecture (ISA) for XT and AT style computers, and the Extended Industry Standard Architecture (EISA) for those computers employing the 80386 microprocessor chip. The ISA and EISA expansion slots are compatible with the ones found in the original IBM XT and AT computers, so the thousands of expansion board products already available will work with them.

WHAT'S IN A PC?

Table 1-1
Standard Microprocessors

Model	Microprocessor
PC	8088
XT	8088, 8086
AT	80286
PS/2	80286, 80386, 80486

Table 1-2.
Typical Microprocessor Speeds

8088	4.77MHz
	6 MHz
	10 MHz~
80286	6 MHz
	12 MHz
	8 MHz
	20 MHz
80386SX	16 MHz
	20 MHz
80386	16 MHz
	20 MHz
80386w/ cache	25 MHz
	33 MHz
80486	25 MHz
	33 MHz

Table 1-3
Data Bus Width

Microprocessor	Data Bus Width
8088	8 bits
8086	16 bits
80286	16 bits
80386SX	16 bits
80386*	32 bits

*80386 w/o suffix assumes DX chip.

Table 1-4 Microprocessors

CPU	Math	Suffix	Speed
8088	8087	none	5 MHz
8086		-3	6MHz
		-2	8 MHz
		-1	10 MHz
80286	80287	-6	6 MHz
		-8	8 MHz
		-10	10 MHz
		-12	12 MHz
		-16	16 MHz
		-20	20 MHz
80386	80387	-16	16 MHz
		-20	20 MHz
		-25	25 MHz
		-33	33 MHz

In addition, those clone computers using the latest whiz-bang microprocessor, the 80486, also incorporate the EISA slot standard.

This Guide tells you how to build your choice of an XT, AT, 80386, or 80486 computer. In actuality, the basic construction of the AT, 80386, and 80486 are nearly identical; they merely use different chips on the main computer board. From here on out in this Guide, when we say "AT," you can assume it also applies to those computers equipped with an 80386 or 80486 microprocessor chip. Furthermore, when we talk about a "PC," we mean the generic personal computer as modeled after the IBM PC line, whether it be an XT, AT, 80386, or 80486.

You should decide ahead of time which type of PC you want to build. While the construction is nearly identical with all types of PC's, the majority of parts are not interchangeable. That makes it difficult for you to change mind half way through the game.

Motherboard

The motherboard is the key component of the computer. It contains the microprocessor, memory, and all other circuitry critical to the basic operation of the computer. With a number of non-PC computer designs, the motherboard contains all or mostly all of the circuitry for connecting the machine to the outside world, displaying text and graphics on a video monitor, and so forth. Not the PC. Its motherboard was designed so that the sub-functions of video display and interconnection to the outside world could be handled by additional circuit boards.

PC clone motherboards have eight slots (some have only five), which accept additional circuit boards (or cards). Two cards absolutely necessary for the operation of your computer are a disk drive controller and display adapter. More about these and other expansion boards in a bit.

The central thinking portion of the computer is the microprocessor. There are five microprocessors commonly used in PC motherboards (all made by Intel):

- The 8088, used in the XT.
- The 8086, used in some versions of XT clones
- The 80286, used in AT clones.
- The 80386.
- The 80386SX, a less expensive and slightly less capable "little brother" to the standard 80386 (the standard 80386 is sometimes referred to as the DX chip,

to differentiate it with the SX chip).

- The 80486.

In addition, a small number of clone motherboards employ Intel compatible microprocessors for the 8088 and 8086. The most common is the NEC V-20, which is compatible with the 8088. The NEC V-30 substitutes for the slightly faster 8086 microprocessor. The main claim to fame of the NEC chips is that they operate a little faster than their Intel counterparts. This increase is supposedly about 30 percent, though in actual use the speed gain may not be that great.

The microprocessor in all computers is governed by a system clock, a quartz crystal regulated device that serves as a kind of electronic metronome. The faster the clock, the faster the computer performs its logic functions. In the basic 8088-equipped XT, the clock rate is 4.77 MHz (4.77 MegaHertz, or millions of cycles per second). On most AT's, the clock speed is at least 8 MHz, although some AT clones run as high as 20 MHz.

Table 1-1 reviews the standard microprocessors used in PC clones and the IBM PS/2 line. Table 1-2 indicates the speeds available with each microprocessor. If budget allows you should purchase a motherboard that operates at the fastest speed as possible, as that will make your computer more efficient. Remember, the faster the chip the higher the purchase price.

Besides sheer clock speed, microprocessors are also judged by the number of data bits they can manipulate at once (this is called the data bus width). The more bits, the faster they can process information. The 8088 microprocessor handles just eight bits at a time.

Conversely, the 8086, 80286, and 80386SX microprocessors handle 16 bits at a time. These chips, therefore, are fundamentally twice as efficient as the 8088. One step up the ladder, the 80386 and 80486 handle 32 bits at once, making them very efficient jugglers of data. Refer to Table 1-3 for an overview of the bit-handling capabilities of PC microprocessors.

If you already have purchased a PC motherboard, one look at it can tell you how fast it runs. First, identify the microprocessor. It is usually one of the largest integrated circuits on the board. It will have one of the numbers indicated above. Following this number is a suffix, such as -10 or -16. This suffix, as indicated in Table 1-4, reveals the maximum operating speed of that chip, and hence, the motherboard.

Taken together — speed and data bus width — one microprocessor is inherently faster than the other. Table 1-5 is a cross-reference chart showing microprocessor type and operating speed, along with the results of two well-known "benchmark" tests. The Norton SI rating is derived from the System Information test, one of the programs included with the Norton Utilities package. The Norton SI rating provides a good ball-park figure useful for broad comparisons. The Landmark AT test is another benchmark that in many ways more accurately reflects the true speed of a computer.

Be aware that the test results in Table 1-5 are typical; your motherboard may fall above or below these results. When in doubt, contact the manufacturer or dealer of the motherboard and ask them how their product fared in the Norton SI and Landmark tests.

An important side-element of microprocessor type is the amount of memory it can access. For obvious reasons, the more memory it can freely access, the more efficient your computer will be. And your computer will be able to run even the most sophisticated programs. Table 1-6 shows the address bus width of the major microprocessors, and the amount of memory each can directly access. The memory is stated in kilobytes and megabytes (more about these shortly), which roughly translate into thousands and millions. For example, the 80286 chip can access up to 16 million pieces of information in RAM, while an 80386 (as well as an 80486) can access up to 4,096 million pieces.

Motherboard Options

On an XT motherboard are a series of option switches and jumpers. In most cases, you needn't bother with the jumpers; they are factory set for the most common configuration (you can always change them later).

The option switches are another matter. These switches tell the XT motherboard what kind of accessories you have attached to it, and how much memory you have installed. The switches are located in one small bank, called a DIP (for Dual In-line Package). The DIP switch package on a clone motherboard has eight miniature switches. You set them with the tip of a pen or other small instrument. See "Putting It Together" for more details on DIP switches.

AT motherboards lack option switches (exception: a few use option switches to indicate the presence of a

Table 1-5 Standard Benchmark Cross-Reference

Microprocessor		Norton SI	Landmark AT Clock
Type	Speed		
Speed			
8088	4.77 MHz	1.	2 MHz
8088	10 MHz	2.1	4.2 MHz
80286	12 MHz	15.3	13.7 MHz
80286	16 MHz	18.7	21.6 MHz
80286	20 MHz	22.5	24 MHz
80386SX	16 MHz	18.	21.8 MHz
80386SX	20 MHz	21.	25 MHz
80386	16	18.7	23 MHz
80386	20	23	25 MHz
80386	25	29	34.5 MHz
80386	25*	36	43.5 MHz
80386	33*	45.9	58.5 MHz

* with microprocessor cache

Table 1-6 Address Bus Width

Microprocessor	Address Bus Width	Maximum Address Size
8086/8088	20	1,024KB (1MB)
80286	24	16,384KB (16MB)
80386SX	24	16,384KB (16MB)
80386	32	4,194,304KB (4,096MB)

math co-processor and/or the type of display used). Rather, AT motherboards are "configured" using a setup program. This program is available either on a utilities disk shipped with the motherboard, or is built into the system and always available. This setup program is accessed in most AT style motherboards by pressing the Escape, Ctrl, and Alt keys simultaneously.

The changes you make in the setup program are stored in a special type of memory called CMOS memory (CMOS integrated circuits are known for their very low power drain). The contents of this memory is maintained by a small battery attached to the motherboard. In most AT systems, the battery has a life expectancy of at least a year, usually longer.

Though AT style motherboards use a setup program instead of a series of switches to set options, most AT motherboards do have at least one or two sets of jumpers that you must alter depending on the type of RAM and ROM chips you have installed (this also applies to most XT motherboards as well). And, some AT clone motherboards come with one or more serial and parallel ports directly on the board. The switches or jumpers

let you specify which of these ports you want to use. Additional options may need to be set, depending on the design of the motherboard. You will need to refer to the manual that came with the board for specific information.

RAM Chips

All computers need memory to store data generated by the software and entered through the keyboard by you. This is the domain of the random access memory (RAM) chips. These integrated circuits serve as temporary holding tanks for data. When the power is turned off, they lose their memory. Long-term memory is accomplished by recording the data on magnetic media — disks. Read below for details on disk drives.

Computer memory is expressed in bytes; one byte equals one letter or other character. The memory in most computers these days is rather vast, with a capacity in the hundreds of thousands or millions of bytes. As a shortcut, memory capacity is rated in thousands of bytes or millions of bytes. A computer with a capacity of roughly 256,000 bytes is said to have a 256K memory. A computer with one million bytes of capacity is said to have 1M (one megabyte) mem-

Table 1-7 Clock Timing

Clock Rate (MHz)	Clock Time (ns)	Recommended RAM (ns)
AT System		
6	167	150
8	125	150
10	100	120
12	83	100
16	63	100
20	50	100
25	40	85
33	30	70
XT System		
4.77	212	200
6	167	150
8	125	150
10	100	120

Table 1-8 Original IBM PC Model Power Supplies

Model	Speed	Power Supply	Number of Slots
PC	4.77 MHz	63.5	5
XT	4.77 MHz	130	8
AT	6/8 MHz	192	8

ory. Note that one thousand bytes is not exactly equal to 1K. Because of the way computers deal with numbers, 1K is really equal to 1,024 bytes. You needn't bother with this disparity in most of the tasks you'll do with the computer, but it is something to keep in mind. The 1K=1,024 bytes topic will become more plain to you in the "Making Sure It Works" section.

Most clones come with no RAM memory already installed, though you can often ask the dealer to pre-install the memory for you. You'll see in ads the board listed as "Motherboard — OK," which means the motherboard is not equipped with any memory.

RAM memory is installed in sets, or banks. You add more sets to increase the memory capacity of the computer. RAM chips have different densities, or the amount of bits of information they can contain. IBM PC clone motherboards can accept a wide variety of RAM chips, including 64K bit, 256K, and 1M bit chips. Note the suffix "bit." Memory chips are rated by the amount of bits they can store, not bytes. In the PC, one byte equals eight bits, so to convert the capacity of each RAM chip into something more meaningful to you, divide by eight. Therefore, a 64K bit chip can store 8K bytes of data; a 256K bit chip 32K bytes of data. And a 1M bit chip can store

128K bytes.

RAM chips are usually installed in sets of nine. Eight chips are required to fulfill the increase of memory. The ninth chip is used by the computer for error checking and correction, called parity.

Unlike the original IBM PC motherboard, which accepts up to 256K of RAM, most all XT clone motherboards come with enough sockets to accommodate a full complement of 640K — the maximum amount you can normally fit into the computer. AT motherboards typically hold up to 1 or 2 megabytes, and 80386/80486 motherboards are designed to hold up to 16 megabytes (though four is the practical maximum).

Because clone motherboards let you socket all 640K on the board, you needn't waste an expansion slot, or pay extra for an add-on board. Note: Some old XT motherboards are designed to accept only 256K of RAM, but these are rare. With the proliferation of 640K motherboards, there is no reason to settle for a 256K version.

Due to the low cost of RAM chips these days, you should equip your system with as much RAM as you can afford. The average cost per megabyte of RAM is currently less than \$75.

RAM chips are further rated by their access time — the time it takes to deliver a piece of information to the micropro-

cessor when requested. Access times are expressed in nanoseconds (ns), or billions of a second. Most XT and AT motherboards accept chips with 120 ns access times; However, faster computers require faster-acting RAM chips, those with access times of 100 nanoseconds or under.

Table 1-7 shows clock time charts for XT and AT (including 80386 and 80486) computers. The Clock Rate shows the operating speed of the microprocessor. The number under Clock Time is the speed, in nanoseconds, or one tick of the microprocessor's metronome. RAM is accessed within no less than two of these ticks, so you can use memory chips slightly slower than the Clock Time. The chart includes the minimum recommended speeds for RAM chips for each microprocessor Clock Rate.

You can tell the speed of the chip by looking at its markings. For example, the notation for most 64K bit chips will read 4164; the notation for 256K bit chips 41256. The suffix after this notation is the speed of the chip, in nanoseconds. A suffix of -20 means 200 ns; -15 means 150 ns; -10 means 100 ns, and so forth. If you are shopping for RAM, look for the fastest chips you can find.

RAM chips and motherboards can be severely damaged if the memory is not installed in the sockets correctly. Be sure to read "Putting It Together" before installing RAM chips in your computer.

Most AT style motherboards are engineered with "wait states." Zero wait states means that the board does not pause during its computations, so there is no loss of computing speeds (fast RAM of at least 100 nanoseconds, preferably less, is required). One to four wait states means that computations are interrupted for one to four periods of time before going on to the next instruction. If you are interested in sheer speed, look for a motherboard that operates at a fast clock speed with the minimum number of wait states.

ROM BIOS Chip

Though the computer is operated by software you feed it through its disk drives, a small portion of programming information is contained in a read only memory (ROM) chip. This memory is permanent; it can't be changed by you or the computer, and its contents remain even when the power to the computer is removed.

The software contained on the ROM chip is the Basic Input/Output System —

BIOS. The ROM BIOS chip is used to properly run software and accommodate expansion hardware. Few motherboards come with the ROM BIOS installed; you do it yourself. The ROM chip is installed in the same manner as the RAM memory chips. Again, you must be careful how you do it. Refer to the "Putting It Together" section before installing the ROM chip in your computer.

The ROM chip plays an important role in the compatibility of the clone when using IBM PC software and hardware. By law, the makers of the ROM chips can't blatantly copy the one in the IBM PC. That one is copyrighted. All of the other chips on the motherboard and expansion boards are off-the-shelf, and available to anyone. To avoid a lawsuit from IBM (not a good idea), the programming code embedded in the ROM chip must be functionally identical to the code in the IBM PC ROM, but it may not be a direct copy. The quality of the programming of the ROM chip determines the overall level of compatibility of the computer.

Fortunately, most ROM chips sold with or available for build-it-yourself clones use a dependable and compatible BIOS. Award, Phoenix, and Hauppauge are three reliable BIOS developers.

Even so, one advantage of building your own computer is that if you find the original ROM chip you installed on the motherboard doesn't provide enough compatibility, you can always change it. ROM BIOS chips follow a standard, so they are interchangeable. The chips may be upgraded by the developer from time to time, to make them more compatible. You can't always visually see the version number or date of manufacture on the ROM chip, but several utilities can be used to read the version date directly from the code inside the chip. See the "Putting It Together" section for more details on these utility programs.

Be sure that the BIOS chip you get is suitable for the motherboard. Obviously, you can't use a BIOS chip designed for an XT in an AT motherboard.

POWER SUPPLY

Power supplies for IBM PC compatible computers are self-contained units, and are usually UL approved (important if the computer is to be used in an office environment where safety regulations must be carefully met). The power supply has its own internal fan to keep the innards of the computer cool. In addition, the power supply may operate an

auxiliary fan located elsewhere in the computer cabinet.

Power supplies are rated in watts, which loosely speaking is the amount of electrical power they can deliver to the computer system. The higher the wattage the better, because the supply will be better able to meet the demands of the various components in the computer. Power supplies for clones generally come with capacities of 95 to 300 watts. All are the about the same size on the outside, and are designed to fit a standard PC or AT case (see below). Buy the largest capacity power supply you can; they provide a greater margin of reserve power should you add to the system.

For your reference, Table 1-8 lists the power supply wattages as used in the original IBM PC, XT, and AT.

Should you opt for the 150 or 200 watt supply? The answer really isn't tough, because the price difference is only \$10 or so. Go for the 200 watt supply. It can handle the computer, four floppy disk drives, a hard disk drive, a tape backup, and still have some reserve power to spare. Using a smaller (in power) supply on a computer that's fully loaded begs for trouble. When the components in the computer don't get adequate power, they behave erratically. You may not be aware that a power problem exists, but the computer may not appear to be working properly, or may have intermittent faults.

There are three general forms of PC power supplies: for XT-style cases, for AT-style cases, and for tower cases. The XT and AT power supplies look almost identical, but their mounting holes, as well as the position of the main switch, fan, and outlets are different.

The type of power supply you get is not really based on the motherboard you use, but rather the case. If the case is for a standard XT motherboard, you should use an XT-style power supply. Those cases suitable for motherboards equipped with an 80286, 80386, or 80486 microprocessor use the AT-style power supply.

Power supplies for the full-size tower cases are similar in design to AT power supplies, but the switch is not connected to the power supply chassis. Rather, the switch is connected to an 18-inch power cord, which stretches to the front of the case. If you are using a full-size tower case, be sure to get the proper power supply for it. Fortunately, tower-cases most often come with the proper power supply already installed.

CASE

The case holds everything together. Cases for PC compatible computers are relatively cheap, consist of all-metal construction, and are designed expressly for clone parts, including the motherboard, disk drives, power supply, and expansion boards.

Note that you should use an XT style case (either slide or hinge) if you are building an XT clone; use any other kind of case if you are building an AT, 80386, or 80486 compatible.

The XT and AT slide tops are like the original IBM cases. You unfasten four or six screws, then slide the top off. The hinge cases have flip tops, like car hoods. The hinge top case makes it easier to access the inside of the computer, handy when you are changing boards or resetting the option switches.

When choosing a case for your clone, make sure it has the proper cutouts (openings) for the power supply, power cable, keyboard, motherboard, and expansion boards. Most all cases do, but you may hit on a poor design that someone is trying to pawn off. Inspect it carefully with the other components of the system. You'll want to "dry fit" the parts together to make sure the case is properly engineered for the components.

At the very least, the case should come with sundry hardware and a transistor radio speaker. The speaker connects to the motherboard to give your computer the power of sound. The hardware lets you attach the motherboard, drives, power supply, and other components properly. Many of the parts are pre-threaded (sometimes with metric threads), so using spare hardware from your garage isn't always a good idea. If the case you are looking at doesn't have hardware, find another that does.

AT-style cases come with additional front-panel hardware, specifically a key-lock (so you can disable the keyboard while you are away) and operation lights. Many of the fancier cases, especially the tower types, come with even more front panel hardware, including reset buttons, turbo setting buttons (to change the motherboard from standard to turbo speed, see the last article in the "PC Tips & Tricks" section), and even a microprocessor digital speed readout. This readout, incidentally, is not entirely accurate. It doesn't really reflect the true operating speed of the microprocessor, just the design speed as set by the system engineer.

If real estate on your desk is a prob-



Typical Case Dimensions

XT style (slide, hinge)
AT style (slide, hinge)
Mini AT
Mini tower
Standard tower

4.25 x 17.75 x 13 (HWD)
6.5 x 21.3 x 18.5 (HWD)
4 x 14.5 x 16.5 (HWD)
14 x 8 x 18 (HWD)
26 X 8 X 18 (HWD)

lem, opt for a small case, like a "baby" AT or tower. These are about 30 percent smaller than their standard size counterparts, but they also lack internal space for additional disk drives. In the standard XT and AT cases, you can fit up to four half-height disk drives in the drive bays; the "baby" styles can accommodate only two and sometimes three. The full-size tower case can usually fit as many as five disk drives.

Keyboard

The keyboard is your direct connection to the computer, your main way of communicating with it. The keyboard connects to the motherboard by way of a standard DIN barrel connector. You can buy any of several keyboards for your clone computer. The basic, "no-frills" keyboard looks just like the one with the original PC. They are usually referred to as "5150-style," after the PC's model number.

Some people don't like the placement and size of some of the keys on the 5150 keyboard. If you're one of those (find out by trying a few keyboards at a dealer), get a 5151-style keyboard. The 10 function keys on this model are located along the top of the keyboard, instead of the left side, and it sports larger Return and Shift keys. Additionally, the

5151 keyboard has separate keypad and cursor keys, making work with a word processor or electronic spreadsheet program a little easier.

Another version of the keyboard available for clone computers, is the model directly copied from the ones that come with the IBM PC/AT. This keyboard is similar in layout to the one on the IBM Selectric typewriter. The AT keyboard is often referred to as an "enhanced keyboard" or the "101 keyboard," for the number of keys it contains.

Keyboards for clones are routinely available starting at about \$60, although the 5151 and enhanced styles cost a little more. You should be aware that many of the keyboards are really cheap, and aren't worth your investment. Most bargain-basement keyboards sold for clones don't have any switches for the keys. Rather, the keys are made out of a spring and a piece of foam. On the bottom of the foam is a slice of aluminum foil. Pushing down a key makes the foil touch bare contacts on the keyboard's printed circuit board.

As a direct result, these keyboards don't have the "feel" of the high-end models found on the real IBM PC, or those made by the major keyboard manufacturers. If you spend your money

on anything, buy a good keyboard for your clone. You may even consider a surplus keyboard, pulled from the stock from one of those unfortunate PC compatible manufacturers that went out of business. Just make sure the keyboard has the proper DIN connector to mate with the clone's motherboard.

Note that keyboards designed for the XT and AT are not directly compatible. You should select the keyboard for the computer you are building (enhanced keyboards work with the AT, 80386, and 80486 computers). A number of keyboards are switch selectable for XT or AT use. The switch is located on the bottom of the keyboard. Set it once for your system and forget it.

Floppy Disks and Controllers

Few computers can do without a floppy disk drive. To add one or more to your clone, you first need a floppy disk controller card. This circuit board, which attaches into one of the expansion slots on the motherboard, supports from two to four disk drives (depending on the card) and serves as the link between the computer and the drive electronics. Like most other expansion boards for the computer, the floppy disk controller gets its power directly from the motherboard.

The floppy disk drives record and play back data on 5 1/4-or 3 1/2-inch diskettes. (Note: Most all controller cards support 3 1/2-inch drives, but the older ones don't, so be sure to check). Table 1-9 shows the various standard floppy drives used on a PC clone, and their respective capacities. Most XT clones use 360K 5 1/4-inch drives, and possibly one 720K 3 1/2-inch drive. AT clones are often equipped with a 1.2M 5 1/4-inch drive, and one 720K or 1.44M 3 1/2-inch drive.

Why all the formats for floppy drives? Compatibility with diskettes created by very old IBM PCs. The first drives for the IBM PC could record data on only one side of the disk. Later, two-sided drives came along, and now they are in the vast majority. The only single-side drives available are those in surplus. The cost may be attractive (\$25 or less) but they severely limit the computer. Opt for the double-sided model.

You can install just one drive when you build your computer, but most people opt for two. Drives are secured to the computer in a compartment in the case. Most drives are half-height, meaning that they take up 50 percent of the vertical space as the old drives. Thus,

you can stack two floppy disk drives in the same area as one of the older drives. Since the case can accommodate two full-height drives, you can fit up to four units in your computer.

The 3 1/2-inch drives are double-sided like the 5 1/4-inch counterpart, but they can record twice the number of tracks on each side of the disk, thus doubling the capacity. The IBM PS/2 computers use 3 1/2-inch drives exclusively, but most generic clones mix the drives so you have a choice of media and can use whatever size of floppy you receive.

Unlike the controller, the drives themselves connect directly to the power supply. Most power supplies have one to four special cables to provide power to the disk drives.

Some drive controllers are designed for the XT only. But most now work with the XT and AT, and support all the drives and formats listed in Table 1-9. Check before you buy, however. Occasionally you may find a floppy disk controller card that does not support the higher capacity 1.2M or 1.44M formats.

Hard Disks and Controllers

Hard disk drives store many times the amount of floppy disk drives. Instead of a capacity of 360K, as with the typical floppy disk drives, or 1.2Mb hard disk drives store 20, 40, 80, or more megabytes of data. By comparison, a medium-capacity 40 megabyte hard disk drive stores over 110 times the amount of data as a 360K floppy disk drive.

Hard drives consist of one or more rigid metal platters; the data is recorded on the platters. On most drives, the platters are not removable, as diskettes are in a floppy drive. The innards of a hard disk drive are sealed and can't be exchanged. That's why hard disks are often referred to as "fixed" disks.

You don't have to install a hard disk drive in your clone, but you'll probably want to if you plan on using your computer for anything more than routine home-based work such as a recipe program or a checkbook balancer. Applications such as electronic spreadsheets and data management cry out for a hard disk drive, because the files you produce with the software can be quite large. Having your data and some or all of your software on hard disk keeps you from having to swap floppy disks in and out of the drives. This saves you time and trouble.

Hard disk drive subsystems come in two parts: the drive itself and a hard disk controller card (just like with floppy

Table 1-9 Floppy Disk Drive Size and Capacity

Disk Size	Tracks/Side	Heads	Sector/Track	Capacity
5.25	40	1	8	160K
5.25	40	1	9	180K
5.25	40	2	8	320K
5.25	40	2	9	360K
5.25	80	2	15	1.2M
3.5	80	2	9	720K
3.5	80	2	18	1.44M

drives). The controller card for the floppy disk drives can't be used to operate a hard disk drive (most drive controllers for the AT are dual function — they operate both floppy and hard disk drives — but such boards are rare for the PC).

The hard disk controller card fits into an empty expansion slot on the motherboard; the hard disk mounts in the disk drive compartment in the case. If you use half-height floppy disk drives, the case will still be able to accommodate a hard disk drive, even one in a full-height package (most drives under 150 megabytes come in half-height packages). A cable links the drive to the controller. The drive is connected directly to the power supply by the same type of cable used to power floppy disk drives.

Some hard disk drives come attached to the controller board — the board and the drive are one unit. You install the "hard-disk-on-a-card" in an empty expansion slot. With this setup, you save yourself from attaching the drive to the case and running cables. The hard disk installs just like any expansion board. With most units, power is derived from the motherboard. Larger capacity hard-disk-on-a-card systems have a separate power tap-off.

Inside Hard Drives

All hard disks share the same basic data recording techniques. A magnetically coated disk spins at high revolution inside the drive. A magnetic pickup head — similar in function to the recording heads in a tape deck but much smaller — hovers over (but does not contact) the disk as it spins.

Data is recorded in concentric tracks. Each track is further divided into sectors. By partitioning the disk into distinct track and sector domains, the computer is better able to efficiently store and retrieve data. Note each track begins and ends at the same place; the read/write head does not record one, long track that spirals from the outside of the disk to the

inside, like a phonograph record.

Higher capacity hard drives use more than one recording disk. The drive is outfitted with a separate read/write head for each side of each disk. Most 40 and 80 megabyte hard drives are equipped with two or three disk platters, and a total of four or six read/write heads.

Hard disks use a voice coil actuator (similar to the driving element in a speaker) to position the read/write heads over the surface of the disk. The exact position of the head is determined by servo signals pre-recorded on the disk. These servo signals are placed either on a separate platter of their own (used only in drives with more than one recording disk), or at strategic points on the surface of the data disk. These points are called sector ID headers.

The loss of one or more sector ID header or servo signal can mean that data recorded at that point on the drive can no longer be accessed. That data could represent a portion of a file that you created years ago and no longer need, or it could represent your latest proposal, the one that took three weeks to write and edit. Losing critical control signals occurs more often than you'd imagine, and is one of the great reasons to invest in a high quality drive.

Older hard drives use a stepper motor to move the read/write heads. Stepper motors don't require servo signals, but they are generally slower than voice coil actuators. Most importantly, stepper motors are not capable of the same fine movement as a voice coil. This determines the overall capacity of the drive.

Three Classes of Hard Drives

The IBM PC/XT was a trail-blazer. This computer came equipped with a 10 megabyte hard drive, which at the time seemed to promise almost infinite data storage capacity. In the days of 64K programs and simple text-only files, 10 megabytes of storage was indeed awesome.

WHAT'S IN A PC?

The hard drive used in the IBM PC/XT set several unofficial standards that are still popular today. This drive used a modified frequency modulation (MFM) recording scheme to place binary data on the disk. The recording method is simple and straight-forward: the drive records a binary 1 as a flux reversal—a change in the direction of magnetic particles on the surface of the disk. A lack of a flux change indicates a binary 0. The MFM recording method, while easy to implement, is rather wasteful of disk real estate, thereby limiting the capacity of the drive.

Recently, other recording techniques have been devised that double and even triple the drive capacity, without adding more recording space. These new approaches are called RLL (run-length limited) and ARLL (advanced run-length limited). The exact nature of the recording techniques employed by RLL or ARLL is beyond the scope of this article, but both work by compressing data into more compact groups. Drives that use RLL recording increase the disk capacity by about 50 percent; ARLL increases the capacity by as much as 75 percent.

Completing the original IBM PC/XT drive was a relatively dumb interface circuit dubbed ST-506 (after the model number given by Seagate, its manufacturer). Actually, the ST-506 was developed before the introduction of the IBM Personal Computer, but its design lent itself well to the architecture of the PC. To this day, the majority of hard disks still use the ST-506 controller (or equivalent) to interface the drive to the computer.

ST-506 interfaces are available in three "flavors": MFM (used most often), RLL, or ARLL. All three will work with any plain-vanilla drive, but some drives are better suited to RLL and ARLL operation than others. If you purchase an RLL or ARLL interface, be sure the drive is rated for the higher capacity.

The second major class of PC drive uses an ESDI controller. The ESDI (Enhanced Small Device Interface) controller is an outgrowth of ST-506, and is considerably faster and more intelligent. A prime benefit of ESDI is its built-in defect mapping. On ST-506 drives, defects in the drives that may cause data loss are reported back to the formatting software, and it is the software's job to make a note of them so they can be avoided in the future. ESDI drives detect the drive defects, and note them

internally, creating a self-contained map so that the drive can steer around the problem areas.

The third class of PC hard disk drives use a SCSI (Small Computer System Interface) controller, or more precisely, a SCSI "host adapter". On a SCSI drive, the disk mechanism and controller electronics are one unit; the host adapter serves to complete the link between the drive and the computer. One of the main benefits of SCSI system is that you can attach up to seven drives to one computer, and each can be actuated individually.

The ST-506 and ESDI systems typically allow you to chain only two drives without resorting to complex addressing schemes. Like ESDI, SCSI sports faster operation. For more information, see the hard disk performance ratings, detailed below.

A relative newcomer to the hard disk arena—but one that has caught on like wildfire—is the IDE drive. Hard drives that use the IDE standard base most of the controller electronics are the drive itself. The controller card contains just a few chips, as well as the single interface cable that connects to the drive.

A number of AT-style and higher motherboards come complete with an IDE interface already built-in. Because IDE drives may not cooperate with other hard drive types in your system, you should be sure that you can disable the on-board IDE electronics should you opt for a different type of hard drive. For example, if you want to use a SCSI drive instead, you are almost guaranteed problems if the motherboard contains IDE circuitry, and the circuitry is not disabled. Generally, the IDE circuits can be turned on and off via a miniature switch or jumper.

On a performance level, IDE drives hold their own against both SCSI and ESDI. On a price level, IDE drives tend to compete favorably with ESDI drives, and are a little cheaper than SCSI drives.

On the downside, as IDE drive technology is rather new, older motherboards may not be compatible with them. If you're looking to upgrade an older XT or AT, check first to make sure you can add an IDE drive. You may need to upgrade the BIOS chip on the motherboard first, which can add \$75-100 to the price.

Think Twice About the Controller

The controller board is the thinking part

of your hard disk drive. To ensure success in selecting your hard drive, keep these points in mind.

Most controllers—ST-506, ESDI, or SCSI—are packaged with the hard drive, so you don't need to buy them separately. This is not true in all situations. When comparing drives, be sure the models you are looking at come with a suitable controller, or that the proper controller is readily available. If you are looking for a second drive to add to your computer, you can compare prices for the disk unit only.

You can safely mix and match ESDI and SCSI drives and controllers, as there is some commonality between them. The same is NOT true of ST-506. Be sure that the controller card matches the drive. This means that the controller is made for the drive, or that the set-up switches on the controller are configured for the drive. This setup allows the controller to correctly communicate with the drive, and takes into consideration the capacity of the drive, the number of disks, number of read/write heads, and other vital information.

Many hard drive dealers package a lesser-brand controller with a name brand drive (Conner driver with a NoName controller, for example), relying on the fact that you'll be too busy worrying about the quality of the drive to think twice about the controller. This is dangerous. In many instances, the quality of the controller is more important than the quality of the disk drive. Take a look at the controller board and watch for signs of shoddy manufacture, or last-minute repairs.

For obvious reasons, the controller must be compatible with the drive you are using. Most hard made these days will work with most any controller, but exceptions do exist. And of course, you need to use an ST-506 drive with an ST-506 controller, an ESDI drive with an ESDI controller, and so forth.

Controllers are designed to operate hard drives only, or a combination of hard and floppy drives. If you already have floppy drives installed in your computer, you don't need (or want) a hard drive controller that supports floppies. Conversely, you can save slot space by using an all-in-one hard/floppy drive controller. Most combo controllers are ST-506 compatible only, and are available for the AT and 80386-class computers, but not the XT or compatibles.

Controllers are specifically designed

for either 8-bit computers, such as the IBM PC/XT or compatibles, or 16- and 32-bit computers, like the IBM AT or clone. A controller made for an AT-class computer won't fit in an XT compatible, and controllers for the 8-bit XT lack the efficiency built into the electronics designed for 16- and 32-bit computers.

Hard Disk Specifications

Hard drives (and associated controller) carry three basic performance ratings: access time, data transfer, and data throughput.

Access time is the average time it takes for the magnetic heads in the drive to go from one track to another, and access data on that track. Access time is stated in milliseconds, or thousandths of a second. A good access time for a voice coil-equipped 40 megabyte hard drive for the AT is 26 to 28 milliseconds (26-28ms). Higher numbers (like 50 or 80 ms) indicate slower access times, which equates to more sluggish performance. Obviously, you'll want the fastest drive you can afford. High speed drives for turbocharged 286 and 286 computers often sport access times in the low teens.

Some manufacturers list peak access time instead of average access time. This specification is worthless, as most any hard drive can access a nearby data track in less than a thousandths of a second. When comparing access time specifications, be sure they reflect the average performance of the drive.

In a real-world application, the access time of a drive is hindered by other factors, including time it takes for the read/write heads to settle in the desired track (called settling time), and the time it takes for the desired cluster of data to pass under the read/write head (called rotational latency).

These two factors can (and often do) reduce the access time performance of a drive by 2 to 10 milliseconds. However, neither settling time nor rotational latency is always considered by the manufacturer when specifying average access. Some manufacturers list the average "seek" time, rather than average "access" time. Seek time does not include settling time and rotational latency.

Access time specifically tied to the design and construction of the hard disk; **data transfer rate** is basically a function of the controller. The transfer rate indicates the amount of data that can be shuttled from hard disk (and controller)

to the computer in one second.

Transfer times are typically stated in millions of bits (not bytes) per second. The higher the number, the better. For example, an ST-506 MFM drive can transfer data at a rate of about five megabits per second; an ST-506 RLL drive can transfer data at about 7.5 megabits per second. Conversely, ESDI drives enjoy a data transfer rate of 10 to 20 megabits/second. The data transfer rate for SCSI drive is on the order of 30 to 40 megabits/second.

The data transfer rate for ESDI and SCSI drives and controllers is sometimes listed in megahertz rather than megabits. While there are differences between the two, roughly speaking, megahertz and megabits are analogous and can be considered to mean the same thing. A drive that transfers data at 15 megahertz passes data between controller and computer at 15 megabits per second.

The data transfer rate is a "best case" specification. Assuming the data is recorded on the drive at the best possible locations, and that no errors occur, the hard disk can supply the computer with xxx number of bits per seconds. But nothing in this world is ideal all the time. The data throughput rate is a more down-to-earth assessment of how much data actually gets to the computer during a one second period.

Data throughput depends on the design of the drive itself, the controller, and your computer. With a reasonably fast computer (a 16 megahertz 80386SX, for example), and a hard drive operating at optimum, data throughput will be closely aligned with the specified data transfer rate of the hard drive and controller. A slower computer may not accept the data at such a high rate of speed, reducing the actual throughput to 75 or 50 percent of the specified data transfer rate.

For obvious reasons, data throughput cannot be indicated for any given hard drive. If you are already attached, you can test the throughput with a suitable hard disk benchmark program (many of these programs are provided with utility programs, including *Norton Utilities* and *PC Tools Deluxe*). Your dealer may be able to provide this information to you before you purchase the computer, so that if the throughput is unacceptably slow for your application, you can either choose a faster computer, or a different hard drive.

Drive Interleave

The interleave of a hard drive partly determines its overall performance. Interleave is a complicated concept, and is determined not only by the hard drive, but by the controller and the computer.

The ideal hard drive, controller, and computer trio uses and interleave of 1:1. Picture each sector for a particular file organized one right after the other along a single data track on the disk. That is, the file starts with sector 1, then goes to sector 2, then 3, and so forth. With an interleave of 1:1, the drive delivers data to the computer at least as fast as it can be collected from the surface of the disk.

If the computer cannot accept data as fast as a hard drive and controller can deliver it (which is usually the case), the sectors must alternate on the disk. For example, a hard drive organized with a 2:1 interleave places a blank sector between each one it records. A file may be stored in sectors 1,3,5,7, and so forth. The blank sectors are filled in later, either with data from the remainder of the same file, or with data from another file.

Interleaves of 17:1 and even higher are not uncommon on IBM PC/XTs and slower AT-type computers.

While you'll want to get a hard disk and controller that support the lowest possible interleave ratio (such as 1:1, 2:1, or 3:1), your computer may be too slow to accommodate the rush of data. All hard disk controllers can shift into slower interleave ratios, but it requires re-formatting—a tedious process.

Display Adapter and Monitor

To hook up a monitor to a PC clone, you need a display adapter card. The two most popular display adapter cards are the monochrome board and color graphics board. Both fit into an expansion slot on the motherboard.

Monochrome cards provide higher quality text than the less expensive color graphics boards, but can't process either color or graphics.

Monochrome cards do have a kind of graphics capability using a set of special graphics test characters, but free-hand design is not possible. Monochrome cards are expressly designed for use with monochrome monitors. These monitors are often referred to as digital or TTL, because they accept the direct digital transistor-to-transistor logic signals from the monochrome board. The monochrome display adapter from IBM comes

Table 1-10. Display Standards

Display Mode	Graphics/Text	Colors/grays	Adapter Type
40 x 25	T	16	CGA, EGA, MCGA, VGA
80 x 25	T	16	CGA, EGA, MCGA, VGA
80 x 25	T	1	CGA, EGA, MCGA, VGA, MDA
720 x 348	G	1	Hercules
320 x 200	G	4	CGA, EGA, MCGA, VGA
640 x 200	G	2	CGA, EGA, MCGA, VGA
320 x 200	G	16	EGA, VGA
640 x 200	G	16	EGA, VGA
320 x 200	G	256	MCGA, VGA
640 x 350	G	1	EGA, VGA
640 x 350	G	16	EGA, VGA
640 x 480	G	2	MCGA, VGA
640 x 480	G	16	VGA
102 x 768	G	256	VGA, XGA

Table 1-11 Video Interface Standards

Display Adapter	Signal Type	Horz. Sync Rate
CGA	RGB	15.75 kHz
MDA/Hercules	TTL	18 kHz
EGA	RGB	21.8, 18, 15.75 kHz
MCGA	Analog RGB	31.5 kHz
VGA	Analog RGB	31.5 kHz

with a parallel printer port, so copycat monochrome boards available for clone computers usually have one as well.

A special kind of monochrome board is the Hercules Graphics Card. These are monochrome boards that can also process high resolution free-hand graphics (with a resolution of 720 by 348 picture elements, or pixels). These, too, have been copied by a variety of companies and are available at competitive prices. The Hercules card is now a standard, and many software packages, most notably Lotus 1-2-3, support it.

Color graphics adapter (CGA) gives you text, graphics, and color, though you get color only with a color monitor. Color graphics cards can hook up to composite video monitors (color or black and white), or to digital (TTL) RGB monitors. The latter provides sharper graphics and text, as well as better color. Some color adapters also come with a parallel printer port.

Color cards display graphics with a resolution of 320 by 200 pixels in color (up to four colors at once on the screen, from a possible palette of 16 colors) or 640 by 200 pixels in black & white. An enhanced graphics adapter (EGA) displays graphics with a resolution of 640

by 350 pixels — about a 50 percent increase — and shows up to 16 colors at a time. EGA boards are dual mode — they offer standard EGA resolution, but also work with all CGA software.

The current de facto display standard is VGA, for video graphics, array. VGA is built into the IBM PS/2 computers and is also available as an add-on board for the IBM PC and compatibles.

The VGA has many modes and resolutions, up to 640 by 480 pixels and 16 colors. When displaying medium-resolution graphics (320 by 200 pixels), the VGA can output up to 256 colors out of a total palette of 262,144 hues.

8- and 16-Bit VGA

Besides various supersets that provide higher resolution, VGA boards come in two distinct flavors: 8-bit and 16-bit. The difference lies in the way the adapter board is electrically connected to the host computer. The established method of connecting a graphics adapter board to the computer is to use an 8-bit port: data is sent to the board eight bits at a time. VGA boards designed for 16-bit operation are fed 16 bits at a time. The extra bits allow faster operation. The analogy is an eight-lane highway compared to a

16-lane highway. Extra lanes allow more cars to travel the road at the same time.

Sixteen-bit VGA adapters flash graphics on the screen faster than ordinary 8-bit adapters. This is particularly handy if you're involved with computer-aided design (CAD), desktop presentations, desktop publishing, or animation.

Multi-Function Adapters

A number of display adapter boards include some or all of the display types mentioned above. A common board is the 5-in-1 VGA adapter. This includes:

- Monochrome display adapter (no graphics, no color)
- Hercules monochrome graphics adapter (no color)
- Color graphics adapter
- Enhanced graphics adapter
- Video graphics array (stand. resolution)

You may select the mode of operation either by setting a set of switches and/or jumpers on the 5-in-1 board or via software, depending on the adapter. You may use up to two different types of single-frequency monitors, such as a monochrome and EGA monitor, or you may use a one multiple-frequency monitor.

For your reference, Table 1-10 lists the various display standards, along with their resolution (text resolution is the number of total characters on the screen; graphics resolution is the total number of pixels on the screen) and maximum number of colors. Note that each display uses its own interface standard, which requires you to always use the proper monitor, or damage to the monitor and/or the display board could result. Table 1-11 shows the video interface standards for CGA, monochrome (MDA), EGA, MCGA, and VGA boards, and the new IBM XGA (Super VGA) standard.

Input/Output

The computer is now almost complete, but unless you've added a monochrome display adapter, it lacks a means of interfacing with printers, plotters, and modems (the monochrome display adapter includes a port for connecting to a parallel interface printer). An input/output (I/O) expansion board provides parallel and/or serial interfaces (ports) for connecting to these and other devices. Most I/O boards have one serial port and one parallel port, but there are boards that offer several of each.

There are two important factors to consider when choosing an I/O board for your clone computer.

You should be able to change the address of the ports (addresses are locations in memory the computer uses to access the ports). Having two parallel ports with the same address, for example, plays havoc on the computer and may cause your programs to crash. Parallel ports can have any of three addresses: LPT1, LPT2, and LPT3. The port on monochrome display adapters is usually set to LPT1 and can't be changed. The parallel port on I/O boards typically have small dual-inline package (DIP) switches or jumpers so that you can switch between any of the available addresses. Serial ports can have either of two addresses: COM1 and COM2. With most all I/O boards, you can change the address of the serial ports by manipulating a set of switches or jumpers.

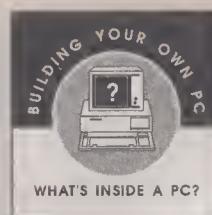
Second, the port connectors on the expansion board should be standard. With the IBM PC, both parallel and serial ports use 25-pin "DB-25" connectors (parallel ports use female connectors; serial ports use male connectors). Having standard connectors helps insure that regular modem and printer/plotter cables will work with your computer. Some I/O boards with serial ports use a DB-9 connector. This is the same connector found on the IBM PC/AT, so it is considered by many board manufacturers to be a standard. You need a connector adapter to mate the board to a standard modem or printer/plotter cable, or else buy a cable with a DB-9 connector already on it.

Multifunction Boards

Many of the functions we've discussed in the previous sections — floppy disk controller, display, and I/O — can be found on one multifunction board. That means you use fewer expansion slots. Multi-function boards also cost less than several separate boards, and they are available in just about every conceivable configuration. The most common provides additional memory (not needed on a clone motherboard), a serial port, a parallel port, a "game" port for attaching joysticks and game-paddles to the computer, and a clock with battery backup (for XT models only; AT models include their own clock with battery backup).

Another popular all-in-one board for clones is the multi-function floppy disk controller card. This board combines a floppy disk controller (usually with a two-drive capacity), a parallel port, and a serial port. Some boards also come with a monochrome display adapter built-in.

Dual-function drive controller boards



Typical Systems

Most parts for do-it-yourself clones are bought separately, although a few companies bundle the bare minimum of components and sell the kit at a package price. To make it easier to decide what you need, refer to the following charts. You'll find several variations on the basic PC clone, and what

components go into making them. For information on optional expansion boards, such as co-processors and internal modems, see the section on Expansion Boards in this magazine.

XT — System 1, Starter:

Motherboard
256K RAM
ROM BIOS
Case
135 watt power supply
IBM PC style keyboard
Floppy disk controller card
One floppy disk drive (5 1/4-inch, 360K capacity)
Monochrome display adapter
Monochrome (TTL) monitor

XT — System 2, Basic Business System:

Motherboard
640K RAM
ROM BIOS
Case
135 watt power supply
AT style keyboard
Dual-function floppy/hard drive controller
Two floppy disk drives (5 1/4-inch, 360K capacity)
One 40 megabyte hard drive I/O board (one each parallel and serial)
Monochrome display adapter
Monochrome (TTL) monitor

XT - System 3, Enhanced Business System:

Motherboard
640K RAM
1M expanded RAM on add-in board
ROM BIOS
Case
150 watt power supply
5151 style keyboard
I/O board (parallel, serial)
Dual-function floppy/hard drive controller
Two floppy disk drives (5 1/4-inch, 360K capacity, 4 1/3- inch 720K capacity)
80 megabyte hard disk drive
VGA adapter
Color VGA monitor

AT — System 1, Starter:

80286 Motherboard
512K RAM
ROM BIOS
Case
200 watt Power supply
Enhanced keyboard
Floppy disk controller card
Two floppy disk drive (5 1/4-inch, 1.2M capacity; 3 1/2inch, 720K capacity)
Monochrome display adapter
Monochrome (TTL) monitor

AT — System 2, Intermediate:

80386SX Motherboard
1M RAM
ROM BIOS
Case
200 watt Power supply
Enhanced keyboard
Dual function floppy/hard drive controller
Two floppy disk drives (5 1/4-inch, 1.2M capacity; 3 1/2- inch 1.44M capacity)
I/O board (one each parallel and serial)
VGA display adapter
Monochrome ("paper white")
VGA monitor

AT — System 3, Enhanced:

80386 or 80486 Motherboard
4M RAM
ROM BIOS
Case
230 watt Power supply
Enhanced keyboard
Dual-function floppy/hard drive controller
Two floppy disk drives (5 1/4-inch, 1.2 M capacity; 3 1/2- inch, 1.44 M capacity)
80 megabyte hard disk drive
VGA display adapter
Color VGA monitor

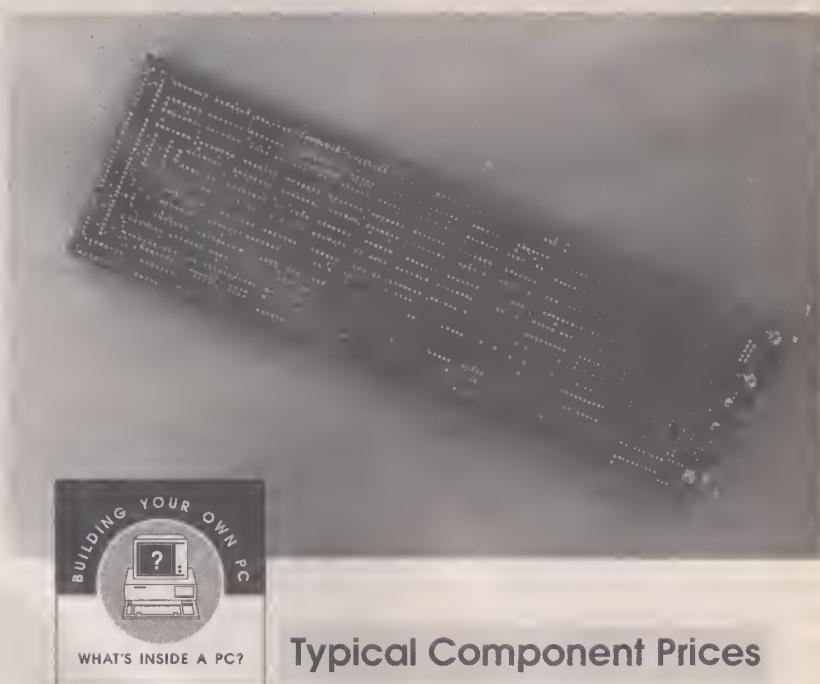
WHAT'S IN A PC?

operate floppy drives and hard drives. These accept one or two floppy drives, and one or two hard drives. The dual-function controller board has become the de facto standard for at least AT clones; you may want to consider one for your computer because of the convenience it provides.

Further Information

Unlike an IBM PC or compatible you buy ready-made, most clones lack any detailed manuals of operation (of course, you pay for these manuals at the higher purchase price for the ready-made computer). With just a few exceptions, however, you can apply the information given in the IBM manuals to your clone.

Refer to these manuals and Guides for further information on using, testing, and servicing your computer. Most are available from IBM dealers and many local bookstores.



Reading List

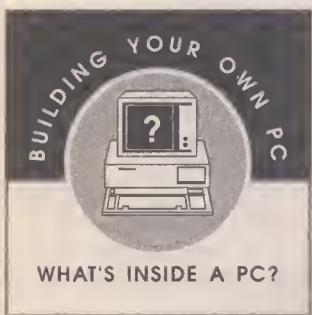
- **Guide to Operations.**
- **Disk Operating System Manual** (PC-DOS), version 2.0 or higher
- **DOS Manual**, version 2.0 or higher
- **Disk Operating System Technical Manual**
- **Hardware Maintenance and Service**
- **Hardware Reference Library Technical Reference**
- **PC Troubleshooting and Repair**, by Bob Brenner (H. W. Sams Co.)
- **PC Configuration HandGuide**, by John Woram (Bantam Computer Books)
- **Upgrading and Repairing PCs**, by Scott Mueller (Que)
- **The Winn Rosch Hardware Bible**, by Winn Rosch (Brady)

Note: You will need a copy of MS-DOS to operate your computer. If your clone doesn't come with a copy, you will need to purchase it. Like most other software packages, the disk operating system is a commercial product, so it isn't free. If you obtain just the operating system and no printed manual, one of the many Guides on MS/PC-DOS should provide all the details you need to know to use the computer. The DOS guides from Microsoft Press and Que are among some of the best. They are available at most all bookstores.

Typical Component Prices

Motherboard		
XT (8088 or 8086)	\$ 55-75	Floppy Disk Controller Card
AT (80286)	100-125	Floppy only \$ 15-25
80386SX	300-375	Hard/floppy 45-65
80386	450-650	
80486SX	650-800	
80486	900+	Hard Disk Drive (Drive Only)
		To:
		20M \$ 175-225
		40M 225-325
		80M 350-450
RAM		
64K DIP	\$ 2	120M \$ 600-650
256K DIP	2-3	250M 850-1150
1M DIP	6-9	
256K SIMM/SIPP	12-16	Monitors
1M SIMM/SIPP	45-60	Monochrome \$ 65-95
Power Supply		
150 watt XT	\$ 30-35	CGA 125-200
200 watt AT	34-45	EGA 200-250
230 watt AT	40-55	VGA/mono std. res 175-225
230 watt tower	60-75	VGA/color std. res 245-300
		VGA 800x600 325-425
		VGA 1024x768 350-500
		Multi-sync 400-750
Case		
Standard XT or AT	\$ 30-40	Display Cards
Baby AT	60-85	Monochrome/Hercules \$ 15-25
Mini tower with PS	85-100	CGA 20-30
Tower with PS	145-175	EGA 45-65
Keyboard		
XT or AT	\$ 35 to 75	VGA 75-125
Floppy Disk Drives		
5 1/4-inch 360K	\$ 40-55	Super VGA 100-225
5 1/4-inch 1.2M	60-85	Multi-function 125-250
3 1/2-inch 720K	55-75	
3 1/2-inch 1.44M	60-85	Input/Output Ports
		Parallel, serial, game \$ 25-45
Miscellaneous		
2400 bps internal modem	\$ 85-125	
Clock/calendar card	20-25	
I/O w/ floppy controller	30-40	

The 80386 and 80486 Powerhouses



WHAT'S INSIDE A PC?

you will want to weigh the pros and cons carefully. Following is some helpful information to guide you when selecting a motherboard for your home-built computer.

Stalking the 386

The latest personal computers are not unlike cars. You can roughly categorize computers along the same lines. The XT-clone is the economy job, retailing for under \$1,000, including monitor and hard disk drive. XT-clones, which use the Intel 8088 (or equivalent) microprocessor, are not known for their power and performance, but they make great entry-level and second computers.

The AT-clone, built around the Intel 80286 microprocessor, is the family sedan. It has adequate power when you need it, but you won't find the AT-clone setting speed records. Cost is about \$1,300, including hard drive and monitor.

Most popular these days are the turbo-charged brutes using the Intel 80386 microprocessor. These combine power with greater flexibility. The '386-based computer readily accepts extra megabytes of memory, and is inherently designed for multi-tasking — doing many different jobs at the same time.

For most people looking for a computer, the '386 fits the bill. Most machines have power to spare, so you can use them with current editions of popular software, like WordPerfect, Lotus 1-2-3, and Microsoft Excel. With extra memory and a math co-processor (the 80387, which is discussed later in this magazine), you can convert any '386 to a personal mini-computer. The '386 makes an ideal network server, for sharing programs, data, and resources among many people.

If you've priced computers lately, you know that the cost of a '386 starts at a low of about \$1,400, and blasts past the \$10,000 mark. Motherboards for build-it-yourself clones cost \$400 to \$1,000, depending on the model.

Two Flavors

There are actually two versions of the 80386 microprocessor. The standard 80386 chip is a full 32-bit microprocessor: it accepts data 32 bits (a bit is a 1 or a 0) at a time, and calculates data 32 bits at a time. The standard 80386 is designed to accommodate multiple simultaneous programs. Using the right software (like Windows 3.0 or the Unix operating system), you can run a word processor and an electronic spread-

sheet at the same time. The microprocessor alternates between the two, crunching numbers here; processing words there.

The second form of the chip is the 80386SX. The 80386SX is functionally identical to the full-grown chip, except that it accepts data only 16 bits at a time. It also lacks some additional technical features of the full 80386. As a result, the 80386SX is about 30 to 40 percent less efficient than the standard 80386. For most applications, this loss of performance is not critical. Only in number-intensive applications like computer-aided design, 3D graphics, or complex electronic spreadsheets does the extra power of the full 80386 really come in handy.

Because the SX chip is the little-brother to the 80386, it costs less, and doesn't require as much support circuitry in the computer. That's why you can buy a '386 computer for \$1,400 — it uses the 80386SX microprocessor.

To make the computer more powerful you can buy a VGA monitor, add \$250 to \$500 for that. And you might also want to add a larger hard disk drive; an additional \$350 buys a reasonably well-made 80 megabyte model. (By the way, these are typical mail order prices; you can do better or worse depending on where you buy.)

A Variety of Speeds

The 80386 chip is manufactured at different speed ratings. The 80386SX sports a speed of either 16MHz or 20MHz (megahertz, or millions of cycles per second). The standard 80386 chip is manufactured for different speeds, specifically 16, 20, 25, and 33 MHz.

The cost for the chip increases as the speed goes up. That increase in cost is reflected in the price of the computer. While you may expect the performance of a computer running at 33 MHz to be significantly higher than one running at 20 or 25 MHz, the difference is not as profound as you may think. While there is a swell in power and performance, the actual increase is only marginally noticeable in most applications.

The performance of a 33 MHz computer becomes more noticeable in calculation intensive applications. These include computer-aided design, numerical analysis, and complex database management. Benchmarks — special programs that test certain facets of the computer — are used to measure the actual power of these turbo-charged computer.

The problem is that benchmarks don't always reflect the kind of performance increase you can expect in an everyday application, like a Microsoft Word or Borland Quattro. You may find that while a super-duper 33 MHz '386 machine is some 40 percent faster in the benchmark tests than a 20 MHz machine, the actual performance increase when using a program like WordPerfect is only 15 to 20 percent, and may not be worth the extra expense. However, you can use benchmark as a guide in helping you choose a nimble computer.

Adding the Add-Ons

Other factors affect the price of a '386 computer. Many of the super-charged 33 MHz '386 computers also sport special high-speed cache memory. This memory is used to temporarily store bits of data for easy access by the microprocessor. Cache memory is seldom over 128K; that doesn't seem like much, but it can have a profound effect in the speed of the computer. The price difference between a cache and non-cache computer is typically around \$300. The increase in performance can be as

TYPICAL BENCHMARK RESULTS

dBASE Test
Index 10,000 records

286 Systems
10MHz = 331 seconds
12MHz = 219 seconds

'386 Systems
16MHz = 197 seconds
20MHz = 153 seconds
25MHz = 102 seconds
33MHz = 78 seconds

'486 systems
25MHz = 61 seconds
33MHz = 35 seconds

Lotus 1-2-3 Test
Recalculate Large
Spreadsheet

'286 Systems
10MHz = 12 seconds
12MHz = 10.2 seconds

'386 Systems
16MHz = 7.6 seconds
25MHz = 5.4 seconds
33MHz = 4.6 seconds

'486 System
25MHz = 4 seconds

Inside the 80486

The 80486 is a microprocessor; the brain of the computer. It's similar in function to the earlier generations of microprocessors — the 8088, 80286, and 80386 (all made by Intel, the leading manufacturer of microprocessors) — except that it contains more transistors than ever before: 1,180,235 of them packed into a sliver of silicon no larger than a postage stamp. In contrast, the first transistorized television sets of the early 1960s contained no more than 10 transistors. And each of these transistors were the size of a kernel of unpopped popcorn.

Like its recent ancestor, the 80386, the 80486 is designed to be operated at blazing speeds. Units coming off the production line are rated at a minimum of 25 MHz; within a few months (by about the time you read this) Intel will ship in quantity a faster version of the 80486, running at 33 MHz.

If you've been following the evolution of super-fast personal computers, you know that the 80386 microprocessor is also available in several speed versions, including 25 and 33 MHz. While it's true that the operating speed of a microprocessor largely determines its nimbleness, the 80486 uses a unique construction that makes it from two to three times faster than an 80386 running at the same speed. At least, the 80486 has the potential for such lightning operation.

How does it do this? The 80486 uses what's known as Complex Reduced Instruction Set Processing (or CRISP) to cut down on the number of "cycles" that contribute to each computing instruction. In chips like the 80286 and 80386, each computing instructions ("take this number and multiply it by 2," for example), consumes from four to six clock cycles. Put another way, one instruction takes place for every four to six beats of the microprocessor's metronome time-keeper.

Conversely, the 80486 performs a complete instruction in under two clock cycles. Simple math reveals that the 80486 is therefore two to three times faster, simply because it can do more work in the same period of time. Think of it as a more efficient gasoline engine. You use the same amount of gas as another car, but the gas is burned more completely and efficiently. The result: more horsepower.

However, simple math alone doesn't make the 80486 two to three times faster than an 80386 running at the same clock speed. In recent benchmark tests, we found that the 80486 ran no more than 40 to 50 percent faster, not the 200 to 300 percent increase Intel has promised.

Why the disparity? The 80486 is designed for software that doesn't yet exist. Both MS-DOS and the current crop of applications programs are designed with slower microprocessors in mind. DOS itself is a severe bottleneck to the 80486, and until DOS is upgraded (or a suitable alternative is available, such as a truly easy-to-use UNIX), the 80486 chip will not run at full capacity.

Structurally, the 80486 microprocessor looks much like the 80386 chip. The new chip does, however, use additional electrical connections (called "pins") and requires some rather hefty support electronics. That means computers using an 80486 microprocessor can't simply be re-designed 80286 or 80386 machines. The entire computer must be re-designed.

That's one reason why computer makers have lagged behind in bringing models to market. Though Intel announced the 80486 chip over a year ago, as of this writing only a handful of 80486 motherboards are available.

Central to the power and performance of the 80486 is a dedicated hardware cache, with much of the circuitry and memory already built into the chip. A cache is a type of

much as 5 or 10 percent.

When comparing prices for '386 computers, remember that not all systems contain the same hardware. A price of \$2,100 for a 386/25 (80386 computer running at 25 MHz) may seem like a really good deal, but be sure you know exactly what you are getting for the price. In most mail order ads, the listed price does not include a monitor, display card, or disk drives — either floppy or hard.

The mail order ads always indicate what's included at the listed price, but you have to read carefully. You can more readily calculate how much you'll spend by figuring the total cost of the system — the basic computer plus the monitor and disk drives. If you're looking for a color system, add \$1,000 to the base price to get a reasonably accurate system price. For example, if the base price is \$2,200, the system price is about \$3,200. That includes VGA color monitor and card, and 40 megabyte hard drive. Add \$750 for a monochrome (Hercules graphics) system.

The 80486: The New Kid on the Block

You've spent months trying to decide which class of computer you should buy. You've looked at 12 MHz 80286-based computers, 16 MHz 80386SX-based machines, even the speed-demon 25 and 33 MHz 80386 hot-rods.

Just when you thought you'd made up your mind, they throw another option at you: the 80486-class computer. Is this new wonderkind worth the effort of even more testing and evaluation? Is it just another marketing ploy by computer manufacturers to increase sales through trade-ups? Do you need the kind of computing power the 80486 microprocessor promises?

The Intel 80486 chip, heart of the latest 80486-based personal computers and workstations, is the newest in the super-fast generation of microprocessors. Computers using the 80486 chip are said to be as speedy as the original Cray supercomputers of the 1960s, and even out-distance many of the main-frame computers running today's successful banks and large corporations.

Let's take a closer look at the 80486 chip, its use in the newest cadre of muscle machines, and how you can benefit from it. You'll learn what this amazing microprocessor can do, and how it can help you.

random access memory (RAM) that's used exclusively by the microprocessor. The 80486 chip uses the cache to hold snippets of instructions. By keeping some data nearby in the cache, the computer doesn't need to access it from the slower standard RAM, or from a hard disk. Cache is now found on most of the faster 80386 computers, and it's found — in one form or another — on all the 80486 machines you'll encounter.

Cache means an increase in effective computing speed of up to 50 percent. But it also means extra cost to you. Though the 80486 has the electronics on-board for caching, most manufacturers supplement it with additional circuitry. On average, the cache adds about \$200 to the cost of the computer. Even more cost is incurred if the computer incorporates circuitry to allow the 80486 to operate in "burst" mode, where it accesses a full 128 bits of cache RAM at a time. This is in contrast to the maximum 32 bits that are accessed by the 80386 chip.

Users of computer-aided design (CAD) and electronic spreadsheet programs will be glad to know that the 80486 has its own built-in math co-processor. Computers using the 80486 don't need a separate math co-processor; you can crunch numbers with your machine right out of the box. That represents a potential savings to you, as long as you have a need for the math functions. Of course, if you don't, that portion of the chip is left unused. But it is there in case you ever need it.

The 80486 in the Real World

Okay, so the 80486 is theoretically two to three times faster than the already speedy 80386 chip. But what does this mean in the real world? How does this speed increase affect the time it takes to recalculate a Lotus 1-2-3 spreadsheet, or scroll to the end of a WordPerfect document?

The 80486 chip is designed for calculation-intensive work, juggling numbers in a Lotus spreadsheet, for example. The 80486 is not as effective in applications that require a lot of data transmission in and out of the microprocessor.

For example, the 80486 can be used in CAD/CAM work for calculating angles, dimensions, and proportions, but it's not as well suited to actually drawing the design on a computer screen. That function is best left to a dedicated graphics controller. In fact, most of the high-end CAD graphics display adapters have their own graphics controllers, to relieve the burden from the computer's main microprocessor of painting pictures on the screen.

Computer makers and consultants often rely on the "benchmark" as a real-world test of the speed and efficiency of a microprocessor. Benchmarks are specially written programs that are designed to test the microprocessor in different ways. The 80486 is such a fast microprocessor that reliable benchmark don't yet exist. For the moment, many computer makers are relying on the old stand-bys: the Norton Utilities System Information (SI) rating, Landmark rate, and the Power Meter MIPS rating.

The MIPS rating, often used with 80486-based computers, tests the number of instructions per second. MIPS stands for millions of instructions per second, and is a different rating than the microprocessor speed, as it takes into account the number of cycles that are required to complete an instruction. A computer equipped with an 80386 running at 25 MHz has a MIPS rating of about 6.2; that is, the chip processes 6.2 million instructions per second. A computer equipped with an 80386 operating at 33 MHz runs at about 8.2 MIPS.

Early tests of a number of 80486 computers show they operate in the region of 15 to 16 MIPS. While these numbers

aren't the highest you'll see in desktop computers (workstations using the Motorola 88000 chip operate at about 17 MIPS), it's plenty fast for just about any application.

What About Compatibility

Compatibility is a thorny issue with all computer users, and for good reason. The average cost of an application program, like Lotus 1-2-3 or WordPerfect, is in excess of \$300. The average business has from three to five of these major applications, for a total cost of about \$900 to \$1,500. That's a lot of money to throw away if the new computer you get doesn't work with your existing software.

Fortunately, Intel designed the 80486 to be completely compatible with the 80386 (this is one reason the chip isn't as fast as it could be). If your software worked on an 80386, there's every reason to believe it will work on an 80486. The latest versions of the popular applications programs are designed for the 80386 in mind, but even if you're stepping up from an 8088 or 80286, your software is still likely to run.

That doesn't mean you won't find a glitch here and there. Intel obviously didn't test the 80486 with all software, nor did it test the chip using every conceivable computer configuration. Before you buy an 80486, ask the dealer if he knows of any problems running your stable of software. Be particularly wary of compatibility problems if you use terminate-and-stay resident utilities, like Sidekick or PC Tools Deluxe Shell. These could refuse to run, or worse, cause some data loss.

Do You Really Need the Power?

No discussion of the 80486 microprocessor is complete without talking about its usefulness in day-to-day business. Do you really need the power of an 80486, or is the blazingly fast speed of the chip useful only as a good conversation piece?

To answer that, you need to analyze your work habits and needs. If you're heavily involved in computer-aided design, or prepare many complex electronic spreadsheets — like budgets for an entire company — then you are a good candidate for an 80486-based computer. But if all you do is type on a word processor all day, it's unlikely you'll ever tap more than 25 percent of the computing power of an 80486 machine. Save your money for another important piece of office equipment, like a fax or a new phone system.

An ideal application of an 80486-equipped computer is a local area network server. Even with a dozen users, an 80486 running at 33 MHz will be able to serve them all with little wait. Operation can become sluggish if several users are accessing large database files, or calculating 50,000-cell spreadsheets.

If you don't have a burning need for an 80486-based computer today, you're better off waiting until prices come down a bit — as they will do as more computer makers come out with competing products.

The first 80386-based computers retailed for over \$8,000; the same models are now routinely available for under \$5,000. There's no reason to doubt that 80486-based computers won't follow the same trend.

When you are ready to buy, tread carefully. The design of the 80486 requires a well-engineered motherboard, that part of the computer that contains most or all the active components. In the old days, with the 8088 and even 80286 microprocessors, motherboards could be designed and even built in someone's home garage. The 80486 requires far more engineering talent, and that is reflected in the quality of the finished product.

Required Skills & Tools

You do not need extensive mechanical or electronic experience to assemble the computer. There is no soldering involved; you just plug in the pieces. If something is wrong with some part of the computer, and you wish to fix it yourself, you will need a basic familiarity with digital logic circuits, as well as a familiarity with digital troubleshooting procedures.

Schematic diagrams of the typical motherboard and keyboard are provided elsewhere in this magazine for those who are curious or wish to delve more deeply in the science and technology of the PC clone.

Before you start building your going to need some tools. This will include include:

- Flat-bladed screwdriver (medium blade).
- Flat-bladed screwdriver (small, jeweler's size).
- #1 Philips head screwdriver.
- Small pen light.
- Assortment of pliers, particularly small needle-nosed pliers

Depending on the design on the case you use, you may need a special Torx screwdriver to remove the metal panels at the back of the computer. Torx screwdrivers are available at Sears, and most hardware stores. In addition, it's a good idea to have several sizes of screwdrivers on hand; use the correct screwdriver for the job and you won't run the risk of stripping the head of the screw. Most assembly — including the case, power supply, motherboard, and disk drives — requires the #1 Philips screwdriver.

Also helpful (but usually not necessary) is a small Crescent (open end) wrench. The wrench helps hold nuts as you tighten down screws, and is sometimes called for when assembling or tightening the hinges on the case. The pliers let you grasp small objects and retrieve hardware that may have fallen into the computer.

If your motherboard does not already have RAM memory and ROM BIOS chips (discussed more fully in the "PC Basics" section), you will need to install them yourself. If you are careful and take your time, the chips can be installed by hand.

However, a more sure and foolproof method is to use an IC inserter tool. The tool is available at most electronics specialty stores, and also usually comes with an extractor. The tool, which costs about \$8, grasps the chip, while curling its metal leads inward for proper insertion. You then position the tool over the socket on the motherboard, and push the chip into



place. There is little chance that the leads of the chip will be bent or broken off. And since you don't actually touch the chip, there is less chance of it being damaged by static electricity (see the warning later in this introduction). The RAM chips can be used with a 14-16 pin IC inserter; the ROM chip will need a 24-28 pin IC inserter.

Besides the minimal technical skills and tools required for the task of building your own computer, you should have a clear, well-lit work

area in which you can comfortably assemble the components. Make sure the area is clean — free of dust, dirt, oil, and grime (the garage is out!) — and that you have plenty of light. Use a bright overhead lamp so you can see every detail as you assemble the parts. If an overhead lamp is not available, gather one or two table lamps, outfit them with 100 watt bulbs, and position them to either side of you. Place the assorted parts directly in front of you.

Recommended Procedure

Assuming that nothing goes wrong during assembly, you should be able to construct your clone in, at most, two to three hours. For best results, follow these guidelines:

- If possible, do all the work in one sitting. A quiet evening, after dinner and when the kids are asleep or doing homework, is a good time. If you leave parts out, they may get lost, stepped on, eaten (by the dog perhaps?) or otherwise destroyed. You will also better maintain your concentration.
- Be sure you have everything needed before you start construction. The section titled "PC Basics" lists the components required for several common systems.
- Have someone else help you. If you can't get someone to help you read through the directions, sort through the parts, and help you put the computer together, at least get a friend or relative to check over your work. To help find possible errors in assembly, refer to the Troubleshooting Charts in the back of this issue. The charts list many common problems and errors.

Read through this guide, as well as the other instructional material that may come with the clone parts, at least once before starting to build. By familiarizing yourself with the entire process, you can avoid making time consuming and potentially costly mistakes. Follow the assembly order given in the Guide. Don't try to skip ahead. If you have a problem, and the computer doesn't operate, recheck your work and try the machine again. If it still doesn't work, consult the Trouble

shooting Charts. On rare occasions, the computer will still refuse to operate. The problem may lie in your construction techniques, but if you have followed instructions and checked your work, the culprit may be a faulty component. The Troubleshooting Charts will help you pinpoint the exact board in your computer that's giving you problems. You can then take the board out and return it for an exchange.

Storm Warnings

If you follow directions and are careful in your work, there is little that can go wrong in the assembly of your PC compatible. To avoid costly mistakes and problems, however, heed these warnings.

Before unpacking and assembly, check the shipping boxes and components for damage. If there are signs of damage on the shipping boxes, the contents inside may be also damaged. Carefully inspect each board, disk drive, and other part, and look for broken or loose connectors, cables, and electronics. Integrated circuits (chips) are usually installed in sockets. During shipping, the chips can work loose from the socket. Gently reseat them back in their sockets. If the integrated circuit is out of the socket completely, return the board for a replacement, or reinstall the chip. The chip goes in one way only, and installing it backward can damage it, and the entire board. Follow the chip installation guidelines in the "Putting It Together" section for more details on how to properly install integrated circuits in sockets.

Not all motherboards, power supplies, keyboards, cases, etc. are standard. Most are, but you may be the unlucky person who buys a non-standard component and tries to integrate it into a working computer system. If you have yet to buy the parts, make sure they fit the descriptions provided in the

following chapters. If they do not, keep shopping. You can avoid a great deal of frustration and extra cost by making sure that the parts are generic, and fit one another (for example, that the power supply correctly fits into the case). If you have already purchased the components, take a few moments to double check that they are standard issue. If they are not, consult with your dealer on how you should assemble the computer. By necessity, this guide covers the construction of a PC clone from standard, generic parts only.

Ground yourself before touching any part of the computer, especially the chips and motherboard. This is especially important in dry areas, where static build-up is a problem. By discharging the static from your body prior to working with the computer, you lessen the chance of blowing an electronic circuit, erasing a disk, or crashing the microprocessor.

DO NOT plug in the power supply until it is connected to the motherboard. The output circuitry of the power supply may be damaged.

NEVER remove or insert an expansion board in the computer when the power is on. ALWAYS turn the power off (unplug the AC cord if possible). Failure to do this will almost certainly cause damage to the expansion board, motherboard, and possibly other components as well.

BE SURE TO INSTALL THE RAM AND ROM CHIPS CORRECTLY. If these chips are installed backwards, they will be destroyed. The motherboard may also be damaged.

If you feel at all uncomfortable building the computer, have someone help you. Enlist the help of a knowledgeable friend, or if your dealer offers the service, have him do it. The \$50 or so charged for assembling the computer goes a long way in giving you peace of mind.

ON SALE NOW

LAPTOP BUYER'S GUIDE

- EVERY MAJOR NOTEBOOK COMPUTER REVIEWED
- ALL 386, 286, AND 8088/8086 PORTABLE COMPUTERS EVALUATED
- EDITORS' BEST BUYS FOR LUNCHBOX, CLAMSHELL & NOTEBOOKS
- OVER 20 PAGES OF COMPARISON CHARTS EXAMINING PRICE, CAPACITY, SPEED, AND MUCH MORE FOR OVER 200 PORTABLE SYSTEMS
- EXCLUSIVE BENCHMARK TESTS TELL WHICH SYSTEMS ARE FASTEST
- ATARI's PORTFOLIO, SHARP's WIZARD, CASIO's B.O.S.S. HANDHELD ORGANIZERS REVIEWED AND BEST BUYS SELECTED

Parts Buyer's Guide

A handy reference that includes shopping tips and a list of vendors that sell the parts you need.

Clone components are available through three main sources: mail order; computer swap meets; and electronics dealers. Let's take a close look at each one.

Mail Order

Most clone components are purchased through the mail. Ads for clone parts are found in *Radio-Electronics*, *Modern Electronics*, *Computer Shopper*, and *Computer Buyer's Guide & Handbook*. Pick up several of the latest issues of these magazines and scour them for the ads. We have provided a number of the more established companies at the end of this section.

You'll find that competition is keen, so the prices for component parts will be similar. You'll seldom see a difference of more than \$10 to \$20 for any particular item. Right before you send in your order, call or write the company and ask for an updated price list. Remember that ads in magazines are placed two to four months before the issue hits the newsstands. The prices may have gone down, and you can save yourself some money by a quick phone call. Most companies will not refund an overage caused by paying the amount stipulated in the ad.

Refer to back issues of the magazines to see how long the company has been advertising (check the newsstand for old copies, or visit the library). We suggest you avoid companies that have been advertising less than two or three months, since they are probably not as well established. A company with a long-running ad history is no guarantee that you will not have problems, however.

Most mail order outlets accept personal checks (they may hold the order for the check to clear), money orders, credit



cards, and COD. COD is one of the best payment methods, because your cash doesn't go out until you have the goods in hand. Unfortunately, a growing number of companies are dropping COD service, claiming it has become too expensive. Customers can refuse the shipment, in which case the mail order firm is stuck with paying the shipping both ways.

Now a bit of stickiness: If you pay by check or credit card, MAIL IN YOUR ORDER. Do not call it in. Here's why. In case of a problem — the order is never shipped or your credit card account is billed for twice the amount of the order — the mail system is your best (if not still feeble) protection. In any case, a written order is better than a verbal one, because there is less chance for error.

Also, your photocopy of the original order (with your credit card number and signature) help you prove your case to the credit card company. You can have improper charges dropped from your credit card account, but you must be quick about it. If you are having trouble with a mail order firm, however rare the occurrence, contact the credit card company within 30 to 60 days. Any longer and you may lose the right to a refund (the credit card company issues you a refund by charging it back to the merchant; if the merchant's Visa or Mastercharge account is empty or closed, you may not get your money back).

If you cannot wait for the mail, one

workable alternative is to fax your order in. You don't have the benefit of the mail systems to help protect you against fraud, but at least the company can fill your order from a written request.

In all fairness, problems with mail order firms are rare, and most difficulties are the result of a lost order, a greater than anticipated response, or a shortage of goods from distributors.

A number of mail order firms have walk-in stores. If you live near one of these (most are in Northern California, Texas, Washington, and the East Coast), make it a point to go in and check out the operation and the merchandise.

When looking over mail order ads, pay close attention to the fine print. Note the following:

- Terms of payment. Does the company accept major credit cards, or just cash? Do they insist on money orders or cashier's checks, or will a personal check be okay (however, assume a one or two week hold on your order while your check clears, even if the fine print doesn't say so).
- Shipping procedure. How does the company ship? UPS? Federal Express? And who pays for the shipping charges? Some of the larger mail order companies pay for shipping, but most tack it onto the final price. Be sure to ask.
- Restocking fees. Many mail order firms charge a percentage for returned items that aren't defective. Officially, this is supposed to discourage "try it before you buy" shopping, and helps defray the shipping, warehousing, and handling costs borne by the mail order company. How much is the restocking fee, and when does it apply? You'll want to steer clear if the restocking fee is unusually high — like 25 percent, which equates to

\$750 on a \$3,000 computer — or if it applies to all returns (you cannot be legally charged for returning defective merchandise, though you often must pick up the shipping charges).

- Service. If there's a problem with your computer how will you get it fixed? Does the mail order company offer a technical support line? The better ones provide a toll-free line.

If these and other pertinent items are missing from the fine print in the ad, call the company. With few exceptions, computer mail order firms operate toll-free order numbers.

You'll need to call anyway to check on the availability of the merchandise you want. You should never assume that just because an item is advertised that the company has an unlimited stock of them. Shipping delays are most often caused by being out of stock, and the mail order company may not volunteer that it's backordered on your item. After all, you may be in a hurry — as most people are — and take your business elsewhere.

Alternatively, you can write a letter to the mail order company and ask about their policies and availability of merchandise. However, most mail order outfits are geared almost exclusively for telephone service. It may take several weeks to receive a response to your letter, assuming you get one in the first place.

In all communications to the mail order company, keep notes of what is said, and retain copies of all correspondence. If you talk to someone at the mail order company, get his or her name, or operator number. Record the time and date of the call, and write a quick summary of what was said. You never know when you'll need this kind of information, and being prepared can help keep you out of trouble.

Unless you pay by personal check, you should expect your order within two weeks. Most companies will hold personal checks for two weeks before filling the order, so your computer parts may not arrive until 3-4 weeks after ordering.

Bear in mind that a mail order company can legally take up to 30 days to fulfill your order without reporting any delay to you. After 30 days, the company is required to inform you of the delay, and ask if you want to wait some more, or receive a refund. Whether or not you want to wait is up to you.

When you receive your shipment, check it immediately for concealed damage. Mail order companies have varying

policies regarding damaged shipments; if the problem was clearly the fault of the shipper, you are often required to contact the shipping company yourself and put in a claim. However, doing so requires paperwork from the mail order company, so it's a good idea to keep an open line of communications with them.

While damage in shipping can and does occur, the most common defects are in workmanship of the merchandise. If at all possible, check the gear as soon as you receive it. Contact the mail order company immediately if anything is amiss. And, as before, keep a record of your calls so you can refer back to them if need be.

Computer Swap Meets

Computer swap meets are becoming more and more popular. They bring together dozens of merchants selling software, hardware, peripherals, books, and other products, mostly at cut-rate prices. Some of the merchandise is used, surplus, or discontinued, but much of it is new, imported directly from Japan, Korea, Taiwan, or Hong Kong. Some of it is made in the U.S.

When buying clone parts at a swap meet, try to choose a merchant who also has a store, or at least a place of regular business. That way, you'll get better service in case of a problem. After all, what happens if you buy all the parts, go home and assemble it, and the computer doesn't work? If the merchant doesn't have a store, you'll have to wait for the next swap meet, and it may not be in your area.

Failing that, get the merchant to provide a telephone number for technical support. Inspect the components prior to leaving, and always get a money back guarantee and a receipt.

If the merchant is an independent with no place of business other than his garage (not uncommon nor necessarily unsavory) and if the swap meet is a two day, weekend affair, try to go on the first day. That night, build the computer. If there are any problems, you can go back the next day and get a replacement or refund.

Electronics Dealers

There are many disadvantages to purchasing PC compatible parts through mail order and swap meets. Sending in a check for \$500 or \$600 to someone you don't know can be a disconcerting thing, and swap meets are one-shot affairs where service after the sale is, at best, an

unknown.

The most reliable way to purchase clone components is through a local electronics dealer. The dealer is near you — part of your neighborhood or town. You can go into the store and inspect the merchandise prior to purchasing, and you don't pay them until you have the goods in hand. If a problem arises, you know where you can return for help.

Hundreds of electronics outlets across the country, with the notable exception of the Radio Shack chain, offer clone parts. You won't know about them unless you look in the right places — newspaper ads, magazine ads, and the phone book. First check the local newspapers, particularly the Sunday edition (the business and sports sections are common spots for advertising computer gear). If you find no ads in the paper, check one of the electronics or computer magazines, either regional or national. Who knows, one of the mail order firms may be local to you and you can drop by and purchase your system personally.

Finally, look in the Yellow Pages under Electronics-Retail. Since these ads probably won't say "Clone Parts," you'll have to call a few stores to locate those that handle build-it-yourself IBM PC compatible computers. You may also want to look in the Surplus heading, for outlets that deal with used and surplus electronics.

Buying clone parts from a specialty electronics store has its advantages and disadvantages. On the negative side, prices are usually higher than swap meets and mail order, because the overhead of the store is higher, and the cost of personally servicing customers is higher. On the positive side, you have a greater chance of getting personal attention and help in case you have a problem.

While we are on the subject, it's useful to note that it is highly unlikely that the local computer store, such as Computer-Land, offers clone components. After all, why sell the parts for \$500 when you can sell the computer ready built for over \$1,000? The profit margin in clone parts is small, and the build-it-yourself components detract from the higher priced machines. You may be able to get peripherals, like video display adapters, cables, and printers, from the local dealer, but not motherboards, disk drives and controller cards.

Guarantees, Warranties, Returns

No matter where you get the parts to your PC compatible, you should get a war-

PARTS BUYER'S GUIDE

ranty or guarantee of some type. The seller should warrant the products for a period of at least 30 days; 90 days is even better. You should be able to return defective goods for a replacement within the warranty period.

All terms should be written down somewhere. If the merchant doesn't have the terms written on a flyer or invoice, get him to jot them down on your receipt. Verbal warranties are meaningless.

The PC Clone and the FCC

You may not realize it, but the Federal government has an interest in your PC clone. Specifically, the Federal Communications Commission is concerned about radio frequency emissions coming from the digital circuits in the computer. All computers sold in the United States must be certified by the FCC and conform to minimum emission standards, just like cars rolling off the assembly line must conform to minimum exhaust standards. If the computer puts out too much radio frequency noise, it doesn't get certified and it is illegal to sell it and use it.

FCC policies concerning computer emissions are complex, and, of course, enforcing them are next to impossible. But as a buyer and builder of a do-it-yourself PC clone, you should know a few facts about the situation.

Many clone components are individually FCC certified. That is, the motherboard, video display adapter, disk drive, and other parts have been sent to the FCC, and the commission has placed their stamp of approval on it. If the component has been certified, it will carry a sticker identifying it as so (the sticker says that the computer complies with Part 15 of the FCC rules). Some components may not be FCC certified, and so don't have the sticker.

However, even though the components themselves are certified, the self-assembled computer is not. Presently, the FCC does not apparently recognize that a computer assembled at home from certified parts is in itself certified. The commission requires that the completed computer be re-certified. This is why most dealers of clone parts won't put the machine together for you. The parts they sell are legally certified, but an assembled computer is not. Unless you plan on certifying the assembled computer with the FCC, don't go into business building and selling them.



CLONE PARTS AND SUBSYSTEMS

ALpc Software & Hardware, 1762 Westwood Blvd, 4th Floor, Los Angeles, CA 90024, (800) 955-2572, (213) 441-2075

Altex Computers, 11342 IH-35, San Antonio, TX 78233, (800) 531-5379, (512) 637-3200

Aplus Computer Inc., 398 Lemon Creek Drive, Unit H, Walnut, CA 91789, (714) 594-1112, (800) 443-5373

Asean Computer Technologies, Inc., 971 Fairway Dr., Walnut, CA 01789, (714) 598-2828

Compuworld, 1443 North Highland Ave., Hollywood, CA 90028, (800) 473-0779

CTI Cosmo Trading Inc., 41-21 28th St., Long Island City, NY 11101, (800) 752-1745, (718) 786-8356

Data Dynamics, PO Box 4129, Blue Jay, CA 92317, (800) 999-1172, (714) 336-5333

Dostech Systems, 2123 Bering Dr., Suite H, San Jose, CA 95131, (800) 888-4496, (408) 436-8681

Essence Group, 17815 Newhope St., #G, Fountain Valley, CA 92708, (714) 456-3110

Excess-3 Computer, 15480 Arrow Hwy, Ste. 201, Baldwin Park, CA 91706, (800) 733-9237

Gems Computers, Inc., 2115 Old Oakland Road, San Jose, CA 95131, (800) 969-9910, (408) 432-7380

Gems Computers, Inc., 2115 Old Oakland Road, San Jose, CA 95131, (800) 743-9333

Harmony Computers, 1801 Flatbush Ave., Brooklyn, NY 11210, (800) 441-1144, (718) 692-3232

Hi-Tech, 6500 NW 15TH Ave., Ft. Lauderdale, FL 33309, (800) 941-6991, (305) 977-6991

Hokkins Systemation, Inc., 131 East Brokay Rd., San Jose, CA 95112, (408) 436-8303

JCC Products, 10675 E. Rush St., S. El Monte, CA 91733, (818) 575-7951

Lyco Computer, PO Box 5088, Jersey Shore, PA 17740, (800) 233-8760, (717) 494-1030

Maximum Performance Computing, PO Box 463, Riverton, UT 84065, (800) 848-0995, (801) 254-9030

Microlab, 23976 Freeway Park Dr., Farmington Hills, MI 48335, (800) 288-7828, (313) 474-7711

Multi-Industry Tech, 14741 Carmenita Road, Norwalk, CA 90650, (800) 366-6481

PC Discount Center, Inc., 4341 DiPaolo Center, Glenview, IL 60025, (800) 245-7453, (708) 390-7450

Rain Wholesaler's Inc., PO Box 450, Orchard Park, NY 14127, (800) 752-9512, (716) 674-6267

Shecom Computers, 22755 Savi Ranch Parkway, Unit G, Yorba Linda, CA 92687, (714) 637-4800

Summit Micro Design, 485 Macara Ave., Suite 901, Sunnyvale, CA 94086, (408) 739-6348

Syntax Computer, Inc., 18535 E. Gale Ave., Industry, CA 91748, (800) 552-8900, (818) 854-6363

Syntax Computer, Inc., 5680 Bandinin Blvd., Bell, CA 90201, (800) 552-8900, (213) 262-1300

Toughcom Inc. Computer & Peripheral, 13932 E. Valley Blvd., Suite B, La Puente, CA 91746, (818) 330-0048

Universal Memory Products, 15411 Red Hill Ave., Suite B, Tustin, CA 92680, (800) 678-8648, (714) 258-2018

Verticon Corp., 2810 NW 27th Ave., Miami, FL 33122, (800) 345-4891, (305) 592-9246

Wintec Industries, Inc., 893 Boggs Ave., Suite D, Fremont, CA 94539, (415) 770-9239

Putting It Together

It's easy to assemble a basic computer, including case, motherboard, power supply, and disk drive.



The Computer Case

If the case is shipped in knock-down form (which is rare), it must first be assembled. Follow the specific instructions supplied with the case for proper assembly. Most cases will come with all the hardware required to mount the disk drives, motherboard, power supply, and other components. Place these items in several small dishes to keep them together and handy.

A common case is the flip-top variety. It has two hinges on either side, located near the rear. The hinges usually consist of nothing more than a self-locking nut and bolt, as depicted in Figure 3-1. Assemble the hinge as directed in the manual that accompanied the case. Be sure to tighten the screws. If the screws are loose, the hinge will come apart at some later date, and the hardware may fall into the computer.

If the case did not come with tooth lockwashers, purchase a variety pack at the hardware store, and use the lockwashers to keep the nuts and bolts secured. Most cases also come with a locking bar, to keep the top locked in the upright position when opened. Install it using the hardware provided. To close the top, pull the hinge of the locking bar toward you. Forcing the top closed without releasing the bar may bend the bar.

If the case comes with rubber grommet feet, install them now. Make sure the mounting hardware for the feet do not excessively protrude into the interior of the case. If so, use other mounting hardware or cut the bolt or screw to size. Ideally, the mounting hardware should be nearly flush to the inside surface of the case.

Bare-bones system come with a power supply and motherboard already in-

stalled in the case. If this applies to you, you can skip the power supply installation step. However, be sure to read about setting up the motherboard. Though the motherboard may already be installed, it may not yet be set up for the system you want to build.

The full-size tower cases usually come with power supply already attached. Do not test the power supply by plugging it in. The power supply must be connected to the motherboard or damage could result.

AT-style cases (including tower cases) typically come with front panel indicators, a keylock switch, and perhaps pushbutton switches for setting "turbo" mode and resetting the computer. Install these if necessary. The wires from the indicators and switches will eventually be connected to the motherboard.

Motherboard

Leave the case for now. Put it aside to make room for the motherboard. Before taking the motherboard out of its shipping box, discharge any static electricity in your body by first touching a grounded, metal object. While handling the motherboard (and all electronic components), do not scuff your feet on the carpet. Otherwise, static may build up in your body. Touching an electronic component may discharge the static through it, and destroy it.

Remove the motherboard from the shipping box and carefully peel off the

protective plastic cover. The plastic is anti-static, so use it as a mat while working with the motherboard. Spread the plastic on the table and gently place the motherboard on it. Inspect the motherboard for signs of damage: loose or broken IC's, chipped circuit board traces, cracked board.

Some of the IC sockets may be empty; this is normal. It does not mean that any ICs have fallen out of their sockets. If you find an IC among the packing materials, then you can be certain that the chip has parted company from the motherboard. You are best advised to return the motherboard for a replacement. You can, if you wish, reinsert the IC. Check the IC number, printed on the top of chip, against the information provided with the motherboard. Locate the corresponding IC number (something like U23 or U13) on the motherboard. Insert the chip as instructed later in this section. Be sure that the chip is properly oriented in the socket. Failure to do this may destroy the chip and possibly damage the motherboard.

Orient the motherboard so that the sockets and ICs are facing up, and the eight long expansion slots are facing away from you. Figure 3-2 shows the overall motherboard, and the various points of interest. The figure is of an XT motherboard, but AT, 80386, and 80486 are not much different.

Install Memory

The next task is to install the memory chips, if they are not already installed for you. Almost all XT clone motherboards allow you to install either 256K or the full complement of 640K of RAM. Most AT motherboards allow you to install either 512K or 1M of RAM.

Figure 3-1 Case Hinge

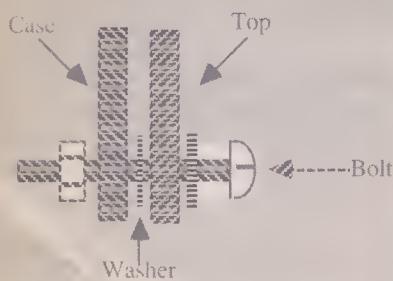
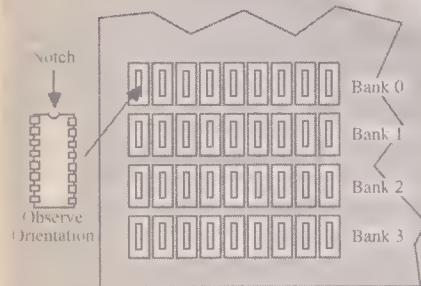


Figure 3-3 RAM Sockets



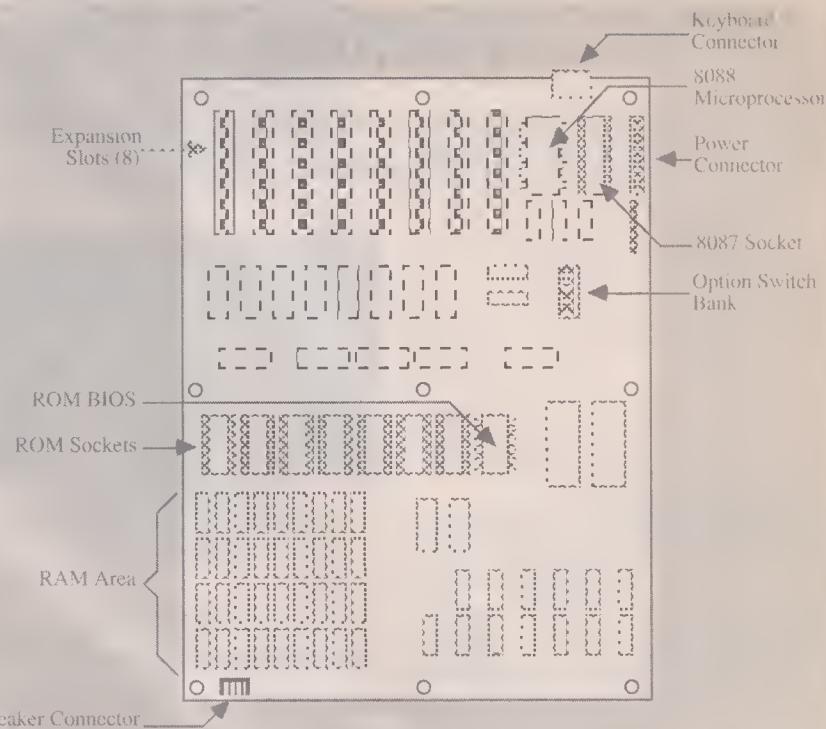
The instructions that follow will assume that you are installing RAM in these increments. The RAM chips are inserted into the four banks of sockets located at the bottom left of the motherboard. The sockets are in rows, as shown in Figure 3-3. The top row is Bank 0, the next row Bank 1, and so forth. The row closest to the bottom edge of the motherboard is Bank 3. Remember this; it is important. As a protection against static electricity, the RAM chips are shipped and stored in conductive foam (usually black). Keep the chips in the foam until you're ready for them.

Installing 640K of RAM into XT

On most XT motherboards, to install 640K of RAM you need eighteen 64K bit chips and eighteen 256K bit chips. The 256K chips are installed in Banks 0 and 1; the 64K chips are installed in Banks 2 and 3. The computer won't work if you install the chips in the wrong banks.

Note the position of the memory chip select jumper. This jumper is used to tell the motherboard which types of RAM chips you are using, and hence the maximum amount of RAM you are installing. Most motherboards are shipped with the jumper in the 640K position, which means you will be using both 64K bit and 256K bit chips.

Figure 3-2 Motherboard



To install a RAM chip, locate its orientation notch in the top of the plastic case. The notch will be on one end. Also locate the notch in the RAM socket (soldered onto the motherboard). The notch of the IC matches the notch in the socket (see Figure 3-4). With most all motherboards, the sockets and IC are oriented so that the notch faces away from you, towards the rear of the board (check the manual that came with the motherboard to be sure your board is the same). In fact, with few exceptions, the chips and sockets on the motherboard should be oriented so the notch is pointing toward the rear, or perhaps the left side. This is assuming you are looking at the board with the memory banks in the lower left corner, closest to you.

To insert the memory, discharge all the static from your body. Being careful to not touch the metal pins of the RAM chips (grab the IC by the ends), remove one chip from the conductive foam packaging. The pins of the chip are flared out to accommodate automatic insertion machinery, so the IC will not fit into the socket unless you press the pins together. Using protective plastic from the motherboard to guard against static, gently press the pins of the IC against the flat surface of the table. Push down gently, alternating between the right and left

side of the chip.

Periodically test the IC to see if it fits in the socket. If the pins are still flared out, push them in some more. When the pins are properly compressed, push the IC GENTLY into the socket, exerting even pressure on the ends. Avoid pushing the chip down on the sides. This will cause one row of pins to seat, while the other is out of the socket. This can bend the pins and cause improper seating of the chip. You will encounter some resistance as the contacts inside the socket spread open to accept the pins of the IC.

To make the job easier, use an IC inserter tool (use the 14/16 pin size with RAM chips). To use, press the end of the tool over the chip, noting the orientation of the notch. Pull the chip out of its protective foam bed. Carefully align the pins of the chip to the holes in the socket. Press the chip into the socket. There is generally no need to manually compress the pins of the IC. The tool does it for you automatically.

Whether you install the chips by hand or by tool, be watchful of IC pins that don't make it into the socket holes. It is entirely possible for one or more pins to curl under or spread out, as depicted in Figure 3-5. Carefully inspect the chip after it has been inserted and watch for pins that didn't make it into the holes. If

the chip was not properly seated, remove it, bend the pin back into place (use a small pair of needle-nose pliers), and try again. Note that once the pin of an IC has been bent, it is softer than the others and may easily curl in again.

You should remove the IC with a small bladed screwdriver or an IC remover. The IC remover is like a giant pair of tweezers; you grasp the chip on either end and pull it out like a tooth. When using a screwdriver, carefully insert the blade between the chip and socket and pry it up. Alternate between both ends to avoid bending the pins any more.

AVOID REMOVING A CHIP WITH YOUR HANDS. Not only do you run the risk of damaging the chip with static discharge, in nine times out of ten you'll yank out the IC using uneven pressure. This causes one end of the chip to come out before the other. You'll bend pins, and some may embed into your skin. Imagine being stung by five or six bees all at once, and you know how it feels to be stabbed by the pins of an IC!

Repeat the process for the remaining chips. Remember these key points:

- Be sure to install the proper size RAM chip (64K or 256K) into the correct bank.
- Be sure each RAM chip is oriented so that its notch matches the notch in the socket.
- Be sure each chip is firmly seated in the socket.
- Be sure that all the pins are inserted in the holes in the socket.

Installing 256K or Less of RAM

If you desire only 256K or less of RAM, instead of the full 640K, use 64K bit chips only. You must also be sure to set the memory chip select jumper to reflect the chip type you are using (most motherboards are shipped with the jumper in the 640K position; check this to be sure). The chip select jumper, which is located near the RAM banks, tells the motherboard you are using all 64K bit chips, or a combination 64K and 256K bit chips. With the four banks filled with 64K bit chips, the maximum capacity of the board is 256K. You DO NOT fill the motherboard with 256K of RAM by installing just one bank of 256K bit chips.

With most motherboards, you remove the jumper when installing only 64K bit chips; you leave the jumper in place when installing both 64K and 256K bit chips. Note that not all motherboards have a memory select jumper. Refer to the manual that came with the mother-

Figure 3-4 RAM Installation

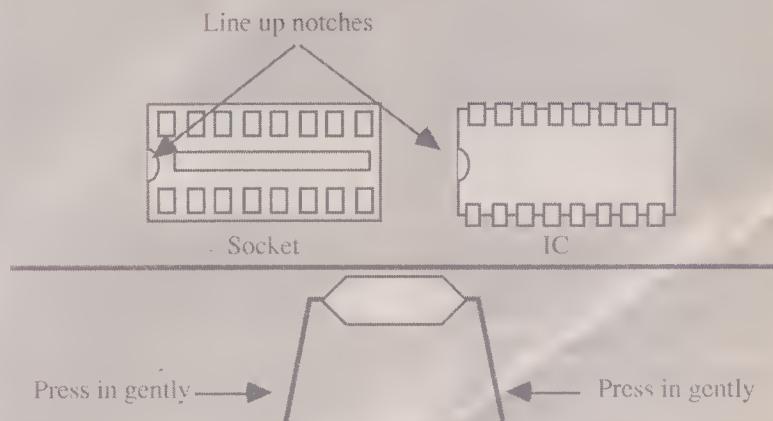
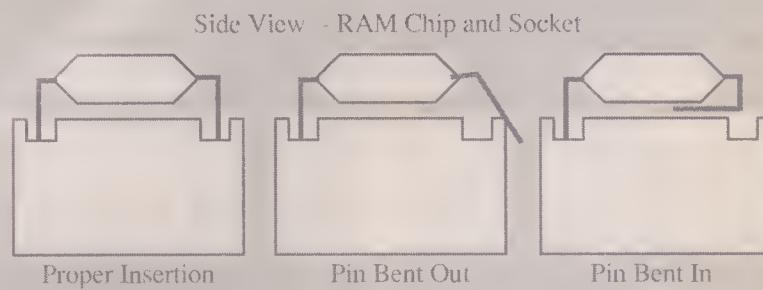


Figure 3-5 Right/Wrong RAM Chip Insertion



board for directions on how to fill it with memory.

Installing 512K or 1M in an AT

Follow the same basic procedure to install either 512K or 1M of RAM in an AT (80286) motherboard. When installing 512K, use two sets of 256K chips; when installing 1M, use four sets of 256K chips.

Installing SIPP or SIMM Memory

Not all RAM is in the form of DIP chips, the kind with two sets of contacts on either side of the integrated circuit. Some AT computers, as well as most all 80386 and 80486 computers use a different form of memory chip called the SIPP or SIMM.

SIMM, which stands for Single-inline Memory Module, contains nine individ-

ual memory chips mounted on a small circuit board. The board includes its own electrical contacts, which mate into special slots on the motherboard. Like DIP memory, SIMMs are available in different capacities as well as physical sizes. Most often, you will use 512K or 1M SIMMs to add memory to your motherboard.

Be sure that the SIMM is the proper size for your board. SIMMs for the IBM PS/2 (and AST) computers are generally not compatible with most clone motherboards. SIMM memory can be installed backwards, so be absolutely sure you insert it into the slot following the instructions provided with the motherboard (usually, but not always, the component side of the module will face the front edge of the motherboard).

SIPP memory, which stands for

Table 3-1.
MATCHING MATH
CO-PROCESSORS

Main Processor	Math Co-Processor
8086	8087
8088	8087
80286	80287
80386SX	80387

Single-inline Pin Package (sometimes referred to as SIP) are very much like SIMM memory. The main difference is that SIPP modules contain a single row of electrical contacts. SIPP memory is not as common in do-it- yourself motherboards as SIMM memory.

Install Microprocessor

Most motherboards already come with the main microprocessor installed. If yours does not, you should install it now. The 8088, 8086, and 80286 microprocessors look like large integrated circuits. These are installed in the same general manner as RAM chips. Be sure to line up the notch in the chip with the notch in the socket.

The 80386 and 80486 chips are inserted in lead-less carriers. You need to locate the reference mark on the top or bottom of the chip (usually a dot) and line that up with the flattened corner of the carrier. Gently insert the chip into place.

Install ROM BIOS

ROM BIOS contains software (called firmware) that the computer uses during all the phases of its operation, even when the machine has just been turned on. The ROM BIOS chip holds this software for easy and fast access by the microprocessor. Some motherboards come with the ROM BIOS chip already installed, but most do not. Fortunately, the task of installing the BIOS chip is an easy one.

The ROM chip is installed into one of the large sockets that spread across the center of the motherboard. The chip has 28 pins, and mates with a 28 pin socket. Almost all motherboards have at least two ROM sockets, although you use only one. The sockets are typically labeled with numbers. Unless the manual that accompanies your motherboard tells you otherwise, install the ROM chip in the socket on the far right, usually ROM1.

Follow the same installation procedure given for RAM chips. Keep the

ROM IC in its conductive foam until you are ready for it. Gently bend the pins inward so they fit into the socket. Manually press the chip into the socket, or use an IC inserter (24/28 pin size). Be sure to match the notch in the chip with the notch in the socket. After the chip has been inserted, carefully check for leads that didn't make it in the holes. If the IC was installed incorrectly, remove it, fix it, and try again.

It is important that you handle the ROM chip with extreme care. Although it isn't more delicate than other chips on the motherboard, it's the most expensive of the bunch (\$20 to \$40). If any of the other chips are damaged, replacing them means an outlay of a few cents to a few dollars. With the ROM chip, you pay for the IC itself and the programming inside it, so it costs more.

Optional Math Co-Processor

The typical PC clone motherboard has room for two processors: the main microprocessor, and an optional math co-processor. The exact math co-processor you get depends on the main microprocessor, as indicated in Table 3-1 (note that the 80486 contains its own built-in math co-processor).

Math co-processors are engineered to perform floating point arithmetic many times faster than the main microprocessor. Applications such as electronic spreadsheets and computer-aided- design (CAD) take advantage of this increase in speed and perform complex number crunching at the wink of an eye. The math co-processor is expensive (usually over \$100), but if you have a use for it, the money is well spent.

As with the main microprocessor, the speed of the math co-processor is rated in MHz. It is usually acceptable to get a math co-processor a notch or two slower than the main microprocessor. This saves some money and the slower speed does not appreciably hinder performance. For example, if the main microprocessor runs as 12 MHz, a 10 or 8 MHz math co-processor is suitable.

In XT and AT motherboards, the math co-processor chip is installed into the large 40 pin socket located in the upper right corner of the motherboard, immediately in front of the keyboard connector. The main microprocessor chip will already be nestled in its socket. You place the math co-processor in the empty socket on the right.

Follow the same installation procedure given for RAM chips. Keep the co-

processor chip in its conductive foam until you are ready to use it. Gently bend the pins inward so they fit into the socket. Manually press the chip into the socket, or use an IC inserter (40 pin size). Be sure to match the notch in the chip with the notch in the socket. After the chip has been inserted, carefully check for leads that didn't make it in the holes. If the IC was installed incorrectly, remove it, fix it, and try again.

Those motherboards equipped with an 80386 or 80386SX microprocessor use the 80387 math co-processor, which is contained in a square multi-pin integrated circuit. The chip is inserted into its respective socket on the motherboard. When installing, match the index mark (a dot or notch) of the math co-processor with the corner notch in the socket.

Note that when the computer is on, the math co-processor can get hot. If the chip came with a clip-on heat-sink, be sure to install it (some chips have the heat-sink permanently glued to the top). The heat sink helps draw heat from the chip package, and dissipates it into the air. Whether or not you install the heat-sink, be sure to keep other components away from the chip. This includes cables, particularly the power supply cable (which connects to the motherboard right next to the math chip!). If the cabling touches the chip, the plastic insulation could melt and cause a short circuit.

Motherboard Checkout

This completes the installation of the chips on the motherboard. It is almost ready to be installed in the case. Before doing so, however, take the time now to double-check your work. Better yet, have someone else check it for you. Have them especially look for improperly installed ICs and bent IC pins.

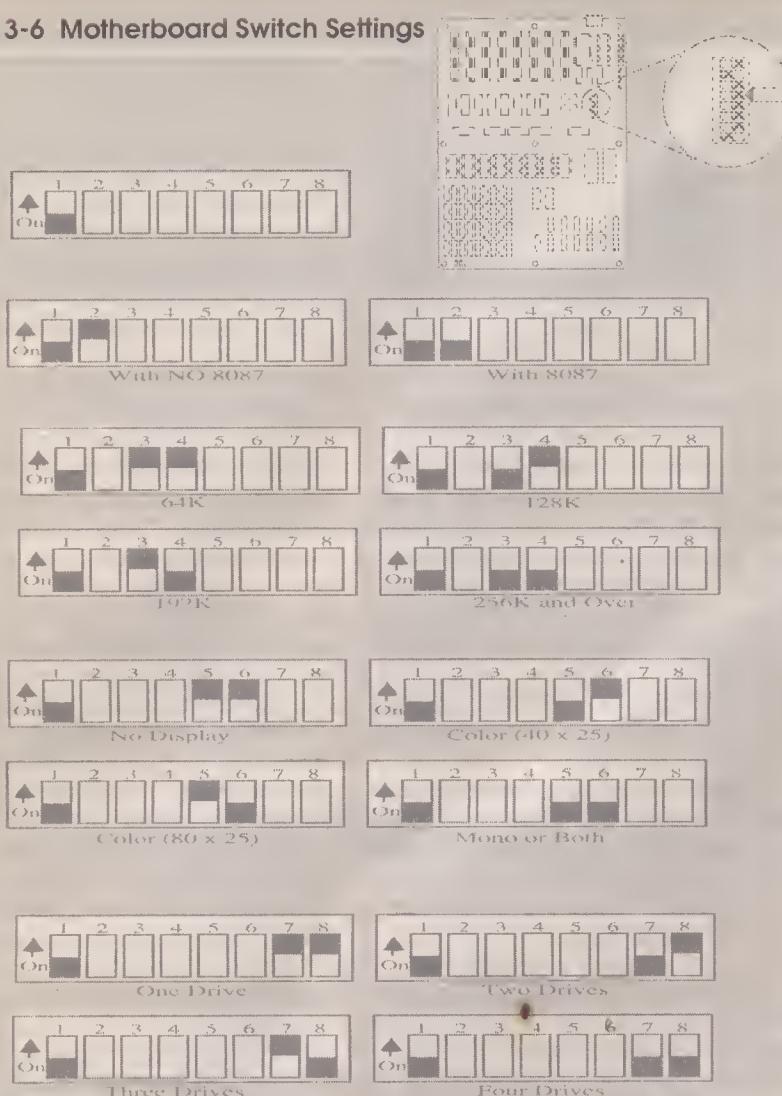
Motherboard Switch Settings

If you are installing an XT motherboard, you must tell it the following:

- The amount of RAM memory available to it.
- The number of floppy disk drives in the system.
- The kind of display adapter used (monochrome or color), and the display mode.
- Whether or not an 8087 math co-processor is installed.

These functions are specified via one eight-position DIP switch. The DIP switch is generally located in the center right portion of the board, about two

Figure 3-6 Motherboard Switch Settings



inches directly under the 8088 chip. The switch is marked from 1 to 8, and ON and OFF (sometimes just on ON, and sometimes 0 and 1 — 0 means off and 1 means on). You set the switches with a blunt instrument, like the tip of a ball-point pen or a manicurist's orange stick, as shown in Figure 3-6. Set the switches as follows.

Switch 1 Switch 1 is usually left in the off position. With some BIOS chips, when the switch is turned to on, the computer is placed in a test mode. Nothing dastardly will occur if the switch is flicked on, so try it so see what it does. Just don't be surprised if nothing happens.

Switch 2 Switch 2 indicates that an 8087 math co-processor has been installed. Note that the logic appears in reverse: the switch is OFF when there is

an 8087 installed; ON with there is no 8087 installed.

Switches 3 and 4 Switches three and four tell the motherboard how much memory you have installed. With most motherboards, you leave switches 3 and 4 off, because you have installed 256K or more of memory. See the figures if you have installed less than 256K of RAM (using 64K bit chips).

Switches 5 and 6 Switches five and six tell the motherboard the kind of display adapter you are using. When using a color adapter, you have the option of normally displaying text in an 80 column by 25 line format (standard) or 40 column by 25 line format (used mostly with a TV set or low-resolution composite video monitor). With both switches off, you can install either a monochrome or a monochrome and color display adapter.

You must direct the display using software commands, as explained in the DOS manual. Some software, such as Lotus 1-2-3, also let you switch between displays from within the program.

Switches 7 and 8 Switches seven and eight tell the motherboard how many floppy disk drives you have installed. The motherboard accepts up to four drives; one and two are the most common. Note that you do not count hard disk drives. For example, if you have two floppy drives and one hard disk drive, you set the switches to reflect two drives. The two floppies are automatically assigned as drives A: and B:. The hard disk is automatically assigned as drive C:.

Should you indicate more drives than you have, the computer will still work but it will let you try to access them. This can cause problems with some software that have poor error trapping routines. In a program like MicroPro's WordStar, for example, trying to access a non-existent drive can force the program to terminate, even while you are writing.

AT Style Installation

If you are using an AT style motherboard (including 80386 and 80486) most of the operating parameters are stored in special CMOS memory. You will need to complete the setup the first time the computer is run.

Many AT motherboards contain a DIP switch for indicating whether a math co-processor is present. Because the DIP switches in AT motherboards are not standardized, you will need to refer to the manual that came with your board. The DIP switch may also indicate the type of display you have connected to the computer, either monochrome or color.

Motherboard Jumper Settings

Jumpers serve a similar purpose as DIP switches, but they are much more simple in design. A jumper can be a circuit board trace on the motherboard; you cut or solder the trace to make or break an electrical connection. Or, as shown in Figure 3-7, it can be a set of terminals that can be electrically connected with a jumper block, a small insulated piece of metal and plastic. Normally, you need not set any jumpers on the motherboard (the same is not true of other boards, such as the hard disk drive controller and I/O card).

One jumper alteration you may need

to make when using an XT motherboard is if you are using all 64K bit chips. A memory chip select jumper is usually left in place if you install all 640K of memory, using both 64K bit and 256K bit chips. The jumper is removed if you install 256K or less of memory, using only 64K bit chips. The location of this jumper varies from one motherboard to another, so check the instructions that came with your board. Some motherboards don't have a memory select jumper.

Remaining jumpers allow you to provide an external power-on reset function and indicate the type of additional ROM chips you have installed. They are discussed below.

Power-On Reset Jumper

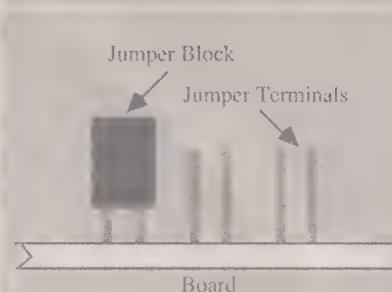
The power-on reset jumper, often labeled JP1 on XT motherboards (different labels on AT motherboards), is used to apply a power-on reset signal externally from the computer. JP1 is located above the slot one furthest to the right. Refer to the schematic or literature that accompanied your motherboard for exact placement. The eyelets will appear as three small splotches of solder. Number the eyelets one to three, starting at the top (furthest edge of the motherboard).

You can also affect a reset of the computer from the keyboard (using most software), by simultaneously holding down the Ctrl, Alt, and Del keys. A reset from the keyboard is known as a "warm boot"; a reset by turning the power off and on, or striking the power-on reset button, is a "cold boot." The two types of resets are different, and affect the computer in different ways. Usually, a warm boot is all that is required. Sometimes, the computer must be cold booted to restart.

EPROM/ROM Jumpers

The motherboard can accept different type of ROM chips (including ultraviolet erasable ROMS, or EPROMS). The chips must be Intel pinout compatible and must not be rated at anything slower than 250 nanoseconds (the smaller the number the faster the rating). Set jumpers W1 through W12 according to the types of ROM/EPROM chips you are installing. In Table 3-2, 0 equals OFF and 1 equals ON. Jumpers W1 through W8 are located immediately to the right of the ROM7 socket (where the ROM BIOS goes). Jumpers W9 through W12 are located above the ROM2 and ROM3 sockets. Note that in most XT and AT

Figure 3-7 Setting Jumpers



motherboards, the ROM/EPROM jumpers are permanently set.

Furthermore, a memory decoder chip, usually designated U23, must be repositioned to reflect the change in ROM chip type. The chip and socket have three positions — A, B, and C, as shown in Table 3-3. With most motherboards, you must unsolder the socket to reposition it. Some motherboards use a socket with additional contacts, so you need only to remove the chip and replant it in a new position.

Yet another jumper is often found on "turbo" XT and AT motherboards. This jumper sets the operating speed default of the motherboards: either standard speed or turbo. You will probably want to set the motherboard to turbo mode. You can always slow it down if needed via software or the keyboard (See the "PC Tips & Tricks" section for a short article on turbomotherboards).

Installing the Motherboard

The motherboard is now ready to be installed into the case. Handle the board only by edges (do not touch any chips or traces), and temporarily place it aside. Position the case in front of you so that the openings of the disk drive compartment are facing you. Lift the case on its side and insert the mounting bolts through the bottom of the case. Secure the bolts on the inside of the case with the threaded stand-offs supplied. The stand-offs are important. They prevent the motherboard from touching the metal case, and shorting out. With a screwdriver, tighten the bolts against the stand-offs.

XT motherboards include six or nine holes. These holes are used to mount the board to the case, using hardware (the hardware is first attached to the case, then the motherboard. Most AT motherboards, and some XT motherboards, are installed with just two screws, both on the center edges of the board. These are

installed simply by placing the board in the case, and tightening the screws. The remaining holes in the motherboard are fitted with plastic spacers. In a few case designs, one end of the motherboard slides under a plastic lip at the bottom of the cabinet. The motherboard is secured in the center by two screws. The other end of the motherboard is supported by two or more plastic stand-offs.

Lay the case back on the table and attach the mounting hardware to it. When installing mounting hardware, place an insulating (plastic or nylon) washer on each standoff and bolt. THIS IS IMPORTANT. Do not forget the insulating washer, or the circuit board traces on the motherboard may contact the case through the bolt and stand-off. If your case didn't come with insulating washers, by all means buy some. Small nylon washers (#6 or #8), available at most larger hardware stores, should do the trick. For XT motherboards you will need a total of eighteen washers; AT motherboards can use just four washers.

Carefully place the motherboard inside the case. When installing an XT motherboard, line up the holes in the board with the bolts and stand-offs. When installing an AT motherboard, line up the holes in the board with threaded holes in the case. The expansion slots on the motherboard should point away from you and line up with the cutouts at the rear of the case.

For XTs, place another round of insulating washers over the small portion of the bolt that extrudes above the motherboard, then secure the assembly with a nut. Do not overtighten. Hand tighten the nut, then tighten another quarter turn with a wrench. For ATs, just insert a screw in the hole and tighten with a screwdriver. Avoid over-tightening.

This is a good time to test the height of the motherboard. Insert a card in one of the slots. With the card firmly seated in the slot, its rear mounting bracket should line up with the corresponding cutout in the case. The top of the bracket of the card should easily rest on the rear of the case. If it does not, loosen the motherboard mounting nuts and gently reposition the board until the bracket matches the cutout.

If the bracket is too high or too low, the motherboard itself is too high or low, so you will have to adjust the height of the stand-offs. Remove the motherboard and adjust the stand-offs. Replace the motherboard, making sure you re-install the insulating washers on both sides. If

Table 3-2. ROM/EPROM Jumpers

W:	1	2	3	4	5	6	7	8	9	10	11	12
2764 EPROM	1	0	1	0	1	0	1	0	0	1	0	1
27128 EPROM	1	0	0	1	1	0	1	0	1	0	0	1
8K x 8 ROM	1	0	1	0	0	1	0	1	0	1	0	1
32K x 8 ROM	0	1	0	1	1	0	1	0	1	1	1	0

you must use metal washers to increase the height of the stand-offs, place them between the case and the stand-off. If placed near the motherboard, a portion of the washer may come in contact with some traces on the board, causing a short circuit.

Connect Battery

AT motherboards require a battery to provide power to the CMOS RAM, which contains vital setup information about the computer. Some motherboards include a small lithium battery; the battery looks about the size of a quarter. However, many motherboards lack a built-in battery, and instead rely on one you add inside the case.

Find the battery pack, fill it with fresh alkaline batteries (usually AA size), and mount it using the supplied hardware or double-sided foam tape to an inside panel of the case. Be sure the battery holder won't interfere with other components. Connect the battery pack leads to the appropriate connection on the motherboard. Be sure to orient the lead correctly. You will probably need to refer to the manual that came with the motherboard for specifics.

Speaker and Card Rails

The case should come with a speaker. This small permanent magnet speaker is mounted on the left front of the case, so that the cone of the speaker faces forward. The mounting procedure differs from one style of case to the next, but usually involves attaching a ring around the speaker magnet, then securing the ring to the case using nuts and bolts. Follow the directions that came with your case for details.

The speaker connects to the motherboard by way of a small jack. The jack is located on the front left side of the motherboard. After the speaker has been installed, plug it into the jack. The jack is polarized, so you can plug it in one way only.

The case should have also come with a set of card rails. These are mounted on the inside left front of the cabinet, opposite the expansion slots. The rails serve to hold the end of whatever expansion card you have installed in the computer. The rails are made of plastic and simply snap into holes on the inside of the case.

Connect Indicators and Switches

If your case comes with front panel indicators and switches, take the time to connect them to the motherboard. You will need to refer to the manual that came with the motherboard for exact hookup instructions, as there are no standards for the connections for LED indicators, key-lock switch, or other front-panel operating switches.

Power Supply

The power supply does as its name implies: it supplies power to the entire computer. The supply is mounted in the rear right corner of the case. Slide the power supply into position, being careful not to strike it against the motherboard. Using the hardware supplied, secure the power supply into place. Most cases and power supplies use four screws on the rear. The switch should fit snugly in the cutout on the right side of the computer; the fan and electrical connections should likewise fit the cutouts on the rear of the case. Most power supplies have six cables coming from them: four are for disk drives, and two are for the motherboard. The set of four disk drive power cables will have three or four wires, colored red, yellow, and one or two black leads. Ignore these for now. Note: your power supply may only have one or two drive power cables. Don't worry about that now.

The motherboard power cables are as follows (the colors may not match):

Cable #1 (P8)	Cable #2 (P9)
Green	Black
Red or Blank	Black
Blue	Yellow

White	Red
Black	Red
Black	Red

You can easily identify the cables because the colors of the leads. Cables #1 and #2 fits the power supply motherboard, as shown in Figure 3-8. This long connector is located on the right side of the motherboard, near the back. The connector accepts both motherboard power cables from the power supply.

Fit the #1 cable furthest to the rear of the board (the "top" of the connector). The #1 cable may have an empty socket. This socket corresponds to the second to the top pin on the connector (see the figure below).

Fit the #2 cable on the connector so that the last red wire is on the bottom of the connector.

As a safety precaution, check the manual to be sure you are properly attaching the power supply to the motherboard. This is one connection you don't want to get wrong!

Be sure you do not reverse the cables and don't skip a pin. Doing either will, more than likely, cause irreparable damage to the motherboard and power supply. The power supply connectors on the cables and motherboard are usually not polarized so they can be reversed. However, most cable connectors are equipped with a locking stub. This stub should face toward the supply (the stub keeps the cable locked seated to the motherboard connector).

WARNING: Do not apply power to the power supply until the cables are attached to the motherboard. The power supply needs to be loaded to operate properly, and turning it on without connecting it to anything can overload it.

If the wires for the two motherboard cables of your power supply don't match those listed above, check the literature that came with the power supply. Match up the cables to the pin assignments for the motherboard power supply connector given in the charts in the "Connector Pinouts" section.

If your case is equipped with an auxiliary fan, connect it to the power supply as recommended in the manual that came with the case and/or motherboard. Usually, this consists of tapping into one of the disk drive power lines.

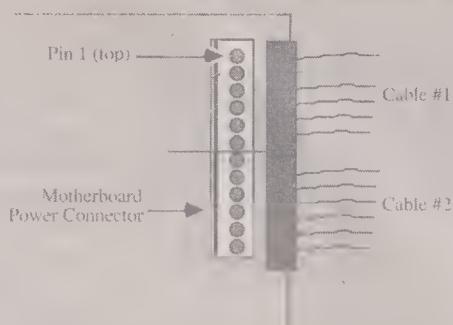
Attach the red lead of the fan to the yellow wire; attach the black lead of the fan to the black wire. If the disk drive power line has two black leads, attach the black wire from the fan to the one nearest

Table 3-3

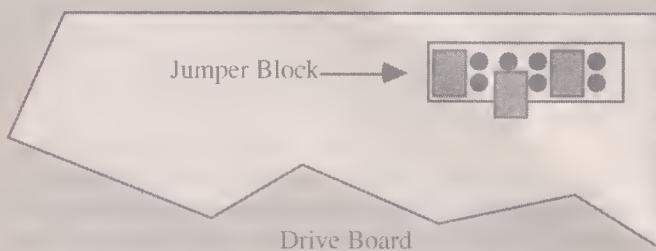
ROM DECODER
CHIP SETTING

Position A	2764 EPROM/ 8K ROM
Position B	27128 EPROM (16K x 8)
Position C	32K ROM (32K x 8)

Figure 3-8 Motherboard Power Supply Connection



3-9 Setting Drive Select Jumpers



the yellow wire.

Consider the power demands of the power supply you are installing. A power supply that doesn't deliver the needed wattage may overheat, burn out, or cause the computer to act unreliably. Table 3-4 shows the power consumption of typical computer hardware, such as the motherboard, extra RAM, and floppy disks. Add up the components you are installing in your system to make sure it won't overtax the power supply. For best results, you should leave a 15 to 20 percent margin.

If you are adding a component that is not listed, or want a more accurate appraisal of the power consumption of your particular system, you will need to look up the amperage draw in the manual that accompanies the component. Multiply that amperage draw by 120 (for 120 volts). The result is the power consumption, in wattage.

Floppy Disk Drives

The next task is to install the floppy disk drive(s). The case will accept either 5 1/4- or 3 1/2-inch drives, at full-, half-, or third-height. Half-height 5 1/4-inch drives are the "standard," and are universally available.

When installing half-height drives, you can stack two drives together, and place them in the right or left drive compartment in the case. With all half-height drives, you can install up to four floppies in your computer. Unless you have a burning need for extra floppy drives, you'll do fine using just two drives and leaving the second compartment empty. The compartment can be used to house a hard disk drive, a streaming tape backup, even an optical CD-ROM drive.

Single Drive Installation

When mounting a disk drive, make sure it is properly oriented. The LED on the faceplate of the drive should be above the disk slot. When installed, the disk motor and flywheel should be on the bottom, not the top.

For ease of installation, mount the drive in the left compartment. If it is a half-height drive, mount it so that it fills the top of the compartment. You will cover the bottom part of the compartment, as well as the right compartment, with a blank plastic bezel. The exact mounting procedure varies, depending on the design of the case, but most use a solid bracket to secure the left side of the drive, and a removable bracket for

the right side.

With the hardware supplied with the case or drive, attach the drive unit to the removable bracket. Do not over tighten the screws. Place the drive in the compartment, and set the bracket into its mating slots in the chassis. Finish the job by securing the left side of the drive to the left bracket. Use the hardware provided.

The drive needs to be told which drive assignment it is being given. In a one-drive system, the disk drive is assigned as drive A. Drives are equipped with a set of jumpers that must be set to reflect the assignment. The jumpers are located on the bottom, rear of the drive, near the edge card connector (see Figure 3-9). It's easiest if you install the drive, then try out the computer. Most drives are shipped from the factory set to drive A, so no changes are necessary.

Should the drive not work, the jumpers will have to be reset. Unfortunately, the jumper style varies from drive to drive, and there is no standard, but on many drives, the labeling of the jumpers will be DS-0 through DS-3 (or possibly DS-1 through DS-4). Drive A: is the first jumper, drive B: the second, and so forth. You will probably need to refer to the technical manual that came with the drive for the exact jumper setting, or else contact your dealer.

The drive may also have a set of terminating resistors. These resistors are packaged as a complete set, and look like an integrated circuit (it may only have one row of pins). Typically, the resistor pack is located on the bottom rear of the drive, beside the drive select jumpers, and is the only component mounted in a socket, for easy removal. On a single-drive computer, the resistor pack should be in place. If it is not, plug it into its socket (if the drive has no resistor pack, you must get one from the dealer).

Dual Drive Installation

When mounting disk drives, make sure they are properly oriented. The LED on the faceplate of the drives should be above the disk slot. When installed, the disk motor and flywheel should be on the bottom, not the top.

The drives must be told which drive assignment it is being given to them. In a two-drive system, one of the drives is assigned as drive A:, the other as drive B. Drives are equipped with a set of jumpers that must be set to reflect the assignment, as explained in the previous section. Before you put the drives in the

computer, however, note the positions of the jumpers. Write them down for safe-keeping in case you ever need to change, add, or take out the drives.

The drives also have a set of terminating resistors. These resistors are packaged as a complete set, and usually look like an integrated circuit. Typically, the resistor pack is located on the bottom rear of the drive, near the drive select jumpers, and is the only component mounted in a socket, for easy removal. Leave the resistor pack on the A: drive; remove it for the B: drive (if neither drive has a resistor pack, you must get one from the dealer).

If you are using full-height drives, mount them in the right and left compartments. By convention, drive A: is on the left and drive B: is on the right. If using half-height drives, mount them both in the left compartment, with drive A: on the top (you can switch the positions if you like, of course). The right drive compartment is left blank, covered with a plastic bezel.

The exact mounting procedure for the drives varies, depending on the design of the case, but most use a solid bracket to secure the left side of the drives, and a removable bracket for the right side.

With the hardware supplied with the case or drive, attach the drive units to the removable bracket. Do not over tighten the screws. Place the drives in the compartment, and set the bracket into its mating slots in the chassis. Finish the job by securing the left side of the drives to the left bracket. Use the hardware provided.

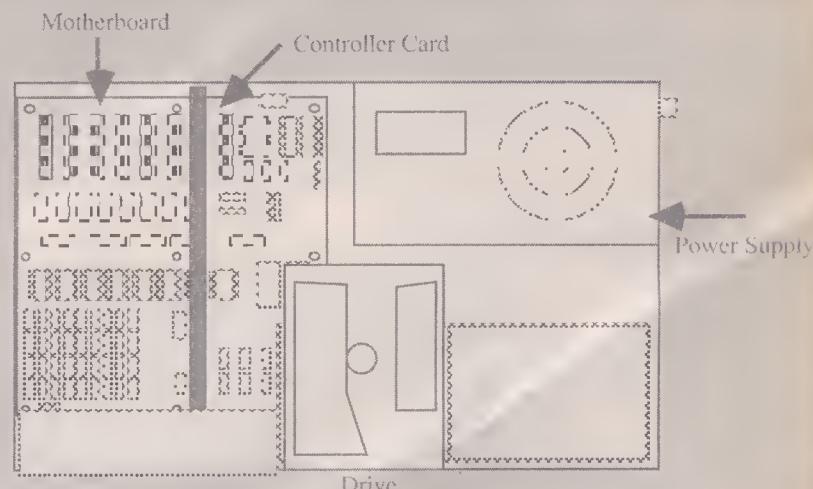
Using Drive Rails

A number of computer cases use rails for attaching disk drives. These make installation much easier, as you need only attach the rail to the sides of the drives, then slide it into position. As the design of drive rails can vary, you will need to consult the manual that came with your case. However, the procedure is generally self-explanatory, so you probably won't need much instruction.

Disk Drive Electrical Connection

The disk drives must be connected to the motherboard and the power supply. Start with the power supply first. Take one of the three-wire power supply cables mentioned earlier, and plug it into the power receptacle on the rear of the drive. The cable and drive connector are polarized; you can insert the cable one way only. Do the same with the other drive, if you

Figure 3-10 Drive Mounting Detail



have it.

Note: Some power supplies have just one cable for the disk drive. If yours is like this, you will need a Y adapter. These split the one cable two ways. The adapter is cheap — under \$4 -- and is available from most clone parts dealers.

Now comes connection to the motherboard. The motherboard itself has no way of interfacing to the drives. That's the job of the disk drive controller card. Remove your controller card from its shipping box and carefully inspect it. Insert it in one of the expansion slots on the motherboard. The best slot is slot 7 (second from the right), because it is close to the disk drives, but is positioned far enough over that the card and its cabling don't interfere with the drives. Secure the floppy disk controller card to the computer by installing and tightening the screw in the bracket. Figure 3-10 shows how the drives and controller should look.

The drive interface cable has three connectors on it. One connector will be by itself at one end of the cable; the other two will be at the other end. Attach the single-end connector to the rear of the controller card. The cable and connector are keyed, so it can be inserted in one direction only. If there is no keying, attach the cable so that the colored stripe (denoting conductor #1 in the cable) is on the top.

The two remaining connectors attach to the drive drive(s). The connector at the very end of the cable attaches to the A: drive, the other connector attaches to the B: drive. Several of the wires on the

connector may be twisted; this is normal.

The drives will not work (but won't be damaged) if the connectors are reversed. As with the controller card, the connectors on the cable and drive(s) are keyed, as shown in Figure 3-11. If there is no keying, orient the colored stripe of the cable so that it matches the notch on the drive connector. With most drives, the notch will be on the outside edge, away from the rest of the drive. Once the cable is attached, tuck it between the drives and power supply, to keep it out of the way. The cable should not interfere with the mechanical parts of the drive(s).

Keyboard

Install the keyboard by plugging its connector into the keyboard socket, located at the rear of the motherboard. The connector goes in one way only.

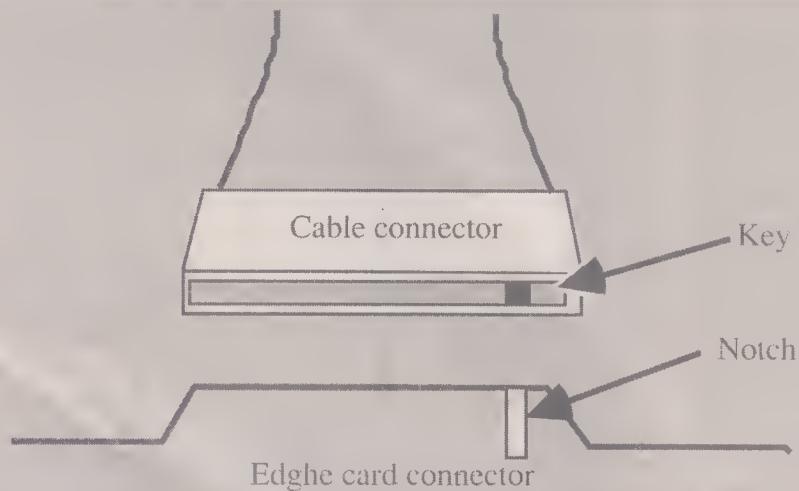
Display Board and Monitor

Install the display board in any of the expansion slots. Good choices for a display board are slots 3 through 6. Slots 1 and 2 may be reserved for a hard-disk-on-a-card (because the card will probably take up more than one slot). Slot 8 should be reserved for an accelerator-co-processor board. Of course, you can place any expansion board into any slot.

Remove your display card from its shipping box and inspect it. Secure the board to the computer by installing and tightening the screw in the bracket.

Attach the monitor to the display board. Most monitors come with the required cable. Be sure to use the proper monitor with the display board you have.

Figure 3-11
Notch-Key in Edge Card Connector & Cable



Don't use a TTL monochrome monitor with a color graphics card.

Cutout Plates

The remaining expansion board cutouts in the rear of the computer should be covered with the plates provided (this helps cut down radio frequency emissions). Install the plates with the hardware that came with the case. Do not over-tighten the bolts.

Inspection

After assembly, resist the temptation to immediately turn the computer on. Recheck your work thoroughly. Spending a few minutes now is well worth the time, energy, and money you'll waste if you did something wrong. Use the checklist that follows for your "quality control" inspection.

- Are the RAM chips oriented so their notches match the notches in the socket?
- Do all the notches point in the same direction?
- Have you installed the proper RAM chips in the banks of the motherboard?
 - Is the memory chip select jumper (if any) set to reflect the type of RAM you have installed?
 - Is the ROM BIOS chip installed so that its notch matches the notch of the socket?
 - Are there any pins of the ROM or RAM chips that are bent and are not entering the socket?
 - Are the DIP switches on the motherboard set properly? Assuming an XT motherboard, do they accurately reflect the amount of RAM? The number of

drives? The type and mode of video display? If an 8087 math co-processor is installed? Is switch 1 in the on position? If so, switch it off.

- Are the insulating washers protecting the motherboard from the metal standoffs and mounting hardware?
- Is the speaker properly mounted in the case? Is the speaker connected to the motherboard?
- Is the motherboard positioned in the case so that expansion boards properly meet the cutouts at the back of the case?
- Is the power supply properly secured?
- Do the power supply switches, fan, and electrical outlets properly match the cutouts in the case?
- Are the jumpers on the drive(s) set properly? For the A: drive? For the B: drive?
- Is the terminator resistor pack set properly on drive A:?
- Is the disk drive controller card installed correctly in the expansion slot? Is it pushed all the way in?
- Is the signal cable connected firmly and properly to the controller card?
- Is the signal cable connected firmly and properly to the drives? The A: drive? The B: drive?
- Is the #1 cable from the power supply properly and firmly connected to the motherboard?
- Is the #2 cable from the power supply properly and firmly connected to the motherboard?
- Are the power supply cables for the disk drive(s) firmly and properly connected?
- Is the video display adapter card in-

stalled correctly in the expansion slot? Is it pushed all the way in?

- Is the video monitor properly connected to the video display card?
- Is the keyboard connector firmly seated in the keyboard jack?
- If you spot any mistakes, correct them now. If all looks fine, connect the power cable between the power supply and a wall outlet.

Finish by plugging in the monitor. Your computer is now assembled! Turn to the next section to learn how to power on the computer and test it. You will need a disk copy of MS-DOS or PC-DOS to perform the tests.

Table 3-4.
Power Consumption in Watts

Motherboard, 640K RAM	96
Motherboard, 2M RAM	108
1M RAM expansion	10
Disk adapter	8
Display adapter	8
Internal modem	6
One floppy disk	7
40M hard disk	12
80M hard disk	15
250M hard disk	27

To calculate power consumption, multiply draw of device (In amps) by 120 (volts). For example, hardware drawing 0.10 amp at 120 volts consumes 12 watts.

PC Upgrade:

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(Please answer all questions)

Expires 4/1/92.

CONFIDENTIAL READER SURVEY

1. What is your company's primary area of business? (Please choose only ONE, from either Section A or Section B.)

A. Non computer-related business:

<input type="checkbox"/> 1 Manufacturing	<input type="checkbox"/> 6-1 Consulting
<input type="checkbox"/> 2 Finance	<input type="checkbox"/> 6-2 Other business services
<input type="checkbox"/> 3 Retail/wholesale	<input type="checkbox"/> 6-3 Transportation, communication, utilities
<input type="checkbox"/> 4 Education	<input type="checkbox"/> 6-4 Military
<input type="checkbox"/> 5 Government	<input type="checkbox"/> 6 Other (specify): _____ 7,8
<input type="checkbox"/> 6 Professional (medicine, law,engineering, architecture)	

B. Computer-related businesses:

<input type="checkbox"/> 9-1 Manufacturer(computers software, peripherals)	<input type="checkbox"/> 1-5 Distributor/ wholesaler
<input type="checkbox"/> 9-2 Computer retailer	<input type="checkbox"/> 1-6 Systems house/ Integrator/VAR
<input type="checkbox"/> 1-3 Consultant	<input type="checkbox"/> 1-7 Other (specify): _____ 10,11
<input type="checkbox"/> 1-4 Service bureau/planning	

2. Which best describes your current job title? (Please choose only ONE.)

<input type="checkbox"/> 12-1 Chairman, president, owner, partner	<input type="checkbox"/> 5 Engineer, planner, systems analyst
<input type="checkbox"/> 12-2 VP, financial officer, treasurer, controller	<input type="checkbox"/> 5-6 Professional (educator, lawyer, doctor, etc.)
<input type="checkbox"/> 13 Director, supervisor, manager	<input type="checkbox"/> 7 Other (specify): _____ 13, 14, 15
<input type="checkbox"/> 14 Microcomputer specialist, micro manager	

3. Which best describes your primary responsibility? (Please choose only ONE.)

<input type="checkbox"/> 16-1 Administration	<input type="checkbox"/> 16 Sales/marketing
<input type="checkbox"/> 16-2 Accounting/finance	<input type="checkbox"/> 17 Purchasing
<input type="checkbox"/> 16-3 Engineering/R&D	<input type="checkbox"/> 18 Operations
<input type="checkbox"/> 16-4 Education/training	<input type="checkbox"/> 19 MIS/OP
<input type="checkbox"/> 16-5 Information center	<input type="checkbox"/> 20 Other (specify): _____ 17,18

4. Please check ALL of the following computers, monitors, hard drives and memory that you currently own.

COMPUTERS:

<input type="checkbox"/> 19-1 XT	<input type="checkbox"/> 3-386
<input type="checkbox"/> 19-2 AT	<input type="checkbox"/> 4-486

MONITORS:

<input type="checkbox"/> 20-1 SVGA	<input type="checkbox"/> 1-3 EGA
<input type="checkbox"/> 20-2 VGA	<input type="checkbox"/> 1-4 CGA

HARD DRIVES:

<input type="checkbox"/> 21-1 20Mb	<input type="checkbox"/> 3 80Mb
<input type="checkbox"/> 21-2 40Mb	<input type="checkbox"/> 4 Above 80Mb

MEMORY:

<input type="checkbox"/> 22-1 640K	<input type="checkbox"/> 1-3 2Mb
<input type="checkbox"/> 22-2 1Mb	<input type="checkbox"/> 1-4 Above 2Mb

5. Which of the following do you use your computer(s) for? (Check ALL that apply.)

<input type="checkbox"/> 23-1 Business
<input type="checkbox"/> 23-2 Hobbies

<input type="checkbox"/> 3-3 Education
<input type="checkbox"/> 3-4 Home/Office

6. Which of the following kinds of software do you currently own? (Check ALL that apply.)

<input type="checkbox"/> 24-1 Spreadsheets	<input type="checkbox"/> 25-1 CAD/CAM/CAE
<input type="checkbox"/> 24-2 Word processors	<input type="checkbox"/> 25-2 Desktop publishing
<input type="checkbox"/> 24-3 Database management	<input type="checkbox"/> 25-3 Utilities
<input type="checkbox"/> 24-4 Accounting packages	<input type="checkbox"/> 25-4 Communications
<input type="checkbox"/> 24-5 Project management	<input type="checkbox"/> 25-5 Font programs
<input type="checkbox"/> 24-6 Personal information managers	<input type="checkbox"/> 25-6 Operating systems
<input type="checkbox"/> 24-7 Graphics/presentations	

7. For what reason(s) did you buy PC UPGRADE? (Check all that apply.)

<input type="checkbox"/> 26-1 To build a system	<input type="checkbox"/> 3-3 For office
<input type="checkbox"/> 26-2 To expand a system	<input type="checkbox"/> 4 For home

8. Please check ALL the peripherals and software you plan to purchase during the next year. (Check ALL that apply.)

Peripherals:

<input type="checkbox"/> 27-1 Dot matrix printer	<input type="checkbox"/> 29-1 VGA monochrome
<input type="checkbox"/> 27-2 Post script laser printer	<input type="checkbox"/> 29-2 Full page monitor (12-14")
<input type="checkbox"/> 27-3 HP laser compatible printer	<input type="checkbox"/> 29-3 Two page monitor (18-21")
<input type="checkbox"/> 28-1 Ink jet printer	<input type="checkbox"/> 4 Scanners
<input type="checkbox"/> 28-2 Thermal printer	<input type="checkbox"/> 5 Additional memory
<input type="checkbox"/> 28-3 Portable printer	<input type="checkbox"/> 6 Accelerator boards
<input type="checkbox"/> 28-4 Fax machine	<input type="checkbox"/> 7 Game cards
<input type="checkbox"/> 28-5 Fax boards	<input type="checkbox"/> 8 Multi-function cards
<input type="checkbox"/> 28-6 LANs	<input type="checkbox"/> 9 Video cards
<input type="checkbox"/> 28-7 Hard Drives	<input type="checkbox"/> 10 Floppy disk controllers
<input type="checkbox"/> 28-8 Modems	<input type="checkbox"/> 30-1 Hard disk controllers
<input type="checkbox"/> 28-9 Motherboards	<input type="checkbox"/> 30-2 CD-ROM drive
<input type="checkbox"/> 28-10 Tape backup system	<input type="checkbox"/> 30-3 Super VGA monitor
<input type="checkbox"/> 28-11 VGA color monitor	<input type="checkbox"/> 30-4 Second floppy drive
<input type="checkbox"/> 28-12 Input device/mouse	<input type="checkbox"/> 30-5 Keyboards

Software:

<input type="checkbox"/> 31-1 Spreadsheets	<input type="checkbox"/> 32-1 CAD/CAM/CAE
<input type="checkbox"/> 31-2 Word processors	<input type="checkbox"/> 32-2 Desktop publishing
<input type="checkbox"/> 31-3 Database management	<input type="checkbox"/> 32-3 Utilities
<input type="checkbox"/> 31-4 Accounting packages	<input type="checkbox"/> 32-4 Communications
<input type="checkbox"/> 31-5 Project management	<input type="checkbox"/> 32-5 Font programs
<input type="checkbox"/> 31-6 Personal information managers	<input type="checkbox"/> 32-6 Operating systems
<input type="checkbox"/> 31-7 Graphics/presentations	

9. After reading this issue of PC UPGRADE, what is the approximate dollar volume you will spend on computer-related products over the course of the next twelve months for both home and/or business use?

<input type="checkbox"/> 33-1 Less than \$2,500	<input type="checkbox"/> 3-3 \$5,000-\$10,000
<input type="checkbox"/> 33-2 \$2,500-\$5,000	<input type="checkbox"/> 4 \$10,000 or more (please specify): _____

10. From what sources will you buy your components, peripherals and supplies? (Check ALL that apply.)

₁ Computer dealer ₄ Direct from manufacturer
 ₂ Super store ₅ Mail order
 ₃ VAR ₆ Other (Specify): _____

35.38

FOR STATISTICAL PURPOSES ONLY:

Your gender: _{57.1} Male ₂ Female

Your age: _{59.1} 18-30 ₃ 51-65
 ₂ 31-50 ₄ Over 65

Your approximate annual income, from all sources, including wages, dividends, interest, etc.

_{59.1} Under \$25,000 ₃ \$50,000-\$99,999
 ₂ \$25,000-\$49,999 ₄ \$100,000 or more

11. When do you anticipate making your next purchases?

Time	Product	Quantity
<input type="checkbox"/> _{57.1} Within 30 days	38.39	48
<input type="checkbox"/> ₂ Within 60 days	40.41.42	50
<input type="checkbox"/> ₃ Within 90 days	43.44.45	51
<input type="checkbox"/> ₄ Within 1 Year	46.47.48	52

12. Which of the following do you participate in? (Check ALL that apply.)

_{53.1} User groups ₂ Regional computer shows (swap meets)

13. Do you ever advise on or recommend computer-related products to:

_{54.1} Business associates ₂ Friends

In your own words, please describe how PC UPGRADE has assisted you:

14. How much time did you spend reading this issue of PC UPGRADE?

_{55.1} Less than 1 hour ₃ 3-5 hours
 ₂ 2-3 hours ₄ More than 5 hours

Your name and address:

Thank you for your help!

60.61

15. After reading this issue of PC UPGRADE, did you:

_{56.1} Save it for future reference ₂ Pass PC UPGRADE on to a co-worker, neighbor, friend or relative



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Making Sure It Works

After the computer is assembled, it must be tested to make sure the components work together correctly.



Some failure conditions may not be immediately apparent to you, especially if you are new to MS-DOS computers. If, at any time, your computer doesn't respond as it should, try the procedure again. If it still doesn't operate properly, check the charts in the "Troubleshooting" section. Note that you should test the computer prior to installing non-critical components, such as an I/O board and hard disk drive. By keeping the computer to its bare minimum, you can more readily deduce the source of faults.

Required Software

All you really need to test your computer is a copy of PC-DOS or MS-DOS. If possible, you should use MS-DOS, be-

cause it is specifically engineered for use with non-IBM PC computers. You can use any version of DOS later than 2.0 (version 3.3 recommended; version 3.2 or above needed if you are using a 3 1/2-inch floppy drive and aren't using driver software for it). The DOS disk should contain all the utilities and transient command programs, including CHDKSK, MORE, and FORMAT.

You can further test the computer with various software utilities and applica-

tions programs. For example, you can examine the sectors of the floppy and hard disk drives with the Norton Utilities, a commercial program available through mail order and in most computer stores. Other utilities do similar jobs.

Start Up

Start your computer by switching the power on. Most keyboards have a "power" light that glows when the computer is on. If your keyboard has such a light, but it does not glow, check the power cable connection, the keyboard cable, or both. Also be sure that the outlet has power. If it is the switched type (operated by a wall switch), turn it on. Once the computer is on, you can power up the monitor.

After a few seconds, the monitor should display a test prompt, something like "Testing Memory" or "Testing I/O." Or, the screen may display a flashing cursor. During this period, the computer is performing a power-on self-test, or POST. The POST checks the memory and expansion boards installed in the expansion slots.

If the POST spots a problem, it usually displays an error message on the screen and sounds a tone (refer to Table 4-1). The computer may or may not operate after this point. Because the POST is controlled by the BIOS, which can differ from machine to machine, it's impossible to provide a full list of possible error messages and solutions here. In any case, the message should be clear enough for you to understand what's wrong. If not, consult your dealer.

Barring any errors, the computer should attempt to boot within 15 to 45 seconds. The more memory and expansion

Table 4-1.

POWER-ON SYSTEM TEST (POST) AUDIO ERROR SIGNALS

* = short tone - = long tone

Audio	Video	Problem
none	none	Power supply
none	cursor only	system board
none	DOS prompt	power supply
*	none	speaker bad
*	PC BASIC on screen	display
*	DOS prompt	disk drive
**	Garbled or blank	A-OK
**	Error code/message	display
short beeps	n/a	Refer to DOS
continuous beep	n/a	error tables
- *	n/a	power supply
- **	n/a	power supply
- ***	n/a	system board
		display
		display

Table 4-2
Interrupt Assignments
for XT Class Computers

Number	Function
NM	Parity check, 8087
0	System timer
1	Keyboard
2	EGA display
3	PC network
3	COM2
4	PC network
4	COM1
5	Voice communications adapter
5	Hard disk
6	Floppy disk
7	Printer (LPT1)

sion boards you have in the computer, the longer it takes. You know it is trying to boot up when the A: drive is activated (the drive motor will spin and the LED on the drive will light up). Because you have yet to insert the DOS disk in the drive, the computer should respond with an error prompt, something like "No Disk in Drive," or "Insert Disk in Drive A and Press Return." Ignore the prompt for the time being.

Flick the monitor off and turn the computer off. Wait about five seconds, then turn the computer back on. Turn the monitor back on.

During the POST, insert the DOS disk in drive A: and close the disk door (or turn the disk handle, thereby locking the disk in place). This time, after the POST is finished and the computer tries to boot, it will (or should) be successful.

If you've assembled an AT style computer, the first time you start up the computer will sense that the setup parameters are missing, and ask you to fill in the blanks. You will need to provide the following information (more information is required for some motherboards; refer to the manual that accompanied the motherboard for more information):

- Time
- Date
- Size and capacity of floppy drives
- Type of hard disk drive, if any
- Amount of RAM
- Type of display adapter (CGA, EGA, etc.)
- Math co-processor present

Once the setup is complete, follow the instructions to save the information, then restart the computer. This time (assuming you are using a genuine formatted

DOS disk) the computer should ask for the time and date. Press Enter (or Return) at these prompts. Finally, the MS-DOS copyright notice should appear, and you should see the ubiquitous:

A>

The "A prompt" indicates that the computer is ready for the next command, and that drive A: is the current logged drive. So far so good.

Testing the Drives

You can be fairly sure that the A: drive works, because the computer was able to boot from it. Try calling the directory by typing:

DIR

and press Enter at the end. After a short wait, the screen should fill with the directory — the contents of the disk. Now test drive B: (if you have a second drive). Remove the disk from drive A: and insert it into drive B:. Make sure that the drive door or latch is closed, or the drive won't be able to read the disk. Type:

B:

and press the Enter when you are finished. Don't forget the colon after the B. You should now see:

B>

signaling that the B: drive is currently logged on. Once again, call the directory. The B: drive should spin, the LED should glow, and the disk contents should appear.

Now thoroughly test the drives by formatting new disks in them. You will need two blank, unformatted disks for this test. Put the DOS disk into drive A: and then log onto that drive. Into drive B: place one of the blank diskettes. Now type:

FORMAT B:/V

This command formats drive B:, and verifies the format. The computer asks you to insert a blank disk in drive B: (if

you haven't already) and press any key. Do so. It will take a few minutes for the disk to be formatted. When finished, the computer will respond with a number of bytes formatted on the disk, and the number of good bytes. The numbers should be the same. If the computer says that there are bad sectors, it's probably the fault of the disk (use certified double-sided disks for this test). Try another disk.

Before you strike a key to commence formatting a disk in the A: drive, remove the DOS disk from the drive and insert a blank, unformatted one. Now you can safely check drive A by formatting another blank disk.

FORMAT A:/V

If you forget to exchange the disks, you'll erase your DOS disk! If you feel you may be the forgetful type, put a write-protect tab on the DOS disk to prevent accidental erasure.

Testing the Sound

With most clones and ROM BIOS chips, the computer should beep once after the POST is complete. If you hear the beep, you know the sound circuits and the speaker are working properly. Even if you don't hear the beep, it doesn't mean that the sound system in your computer is inoperative. However, it could be a strong indication that the computer is not operating properly. Usually, the BIOS will report the error as an error code, as depicted in Table 4-4.

Testing the Display

Obviously, the display works because you can read what you are typing into the computer, and what the computer is responding with. If you have a color graphics board and color monitor, you may want to test for proper operation by using a program that has color output. Again, a

Table 4-3. Interrupt Assignments for AT Class Computers
(also applies to most 80386 and 80486 computers)

Number	Function	Number	Function
NMI	Parity check	7	Data acquisitions adapter
0	System timer		General purpose interface
1	Keyboard		bus adapter
2	Cascade input for second interrupt chip (IRQ 8-15)		Voice communications adapter
3	COM2	8	Real-time clock interrupt
	PC network	9	PC network
4	COM1	10	Reserved
5	LPT2	11	Reserved
6	Diskette controller	13	80287 co-processor
	Hard and floppy drive	14	Hard disk controller
7	LPT1	15	Reserved

Table 4-4. IBM Diagnostic Error Codes
(x or xx = any number; 00 means tested ok with diagnostic software)

Error code	Problem
01x	Undetermined
02x	Power supply
1xx	System board
2xx	Memory
nn 2xx	Memory (nn indicates memory chip)
3x	Keyboard
nn 3xx	Keyboard (nn indicates specific key)
4xx	Monochrome display adapter or monitor
5xx	Color graphics display adapter or monitor
6xx	Disk drives and/or controller card
7xx	Math co-processor
8xx	Reserved
9xx	Parallel port (LPT1)
10xx	Parallel port (LPT2)
11xx	Async port (COM1)
12xx	Async port (COM2)
13xx	Game adapter
14xx	IBM graphics printer
15xx	SDLC camm. adapter
16xx	Reserved
17xx	Hard disk and/or controller
18xx	Expansion unit (PC, XT)
19xx	3270 PC expansion card
20xx	BSC adapter
21xx	Alternate BSC adapter
22xx	Cluster adapter
23xx	Reserved
24xx	Enhanced graphics adapter or monitor
25xx	Alternate EGA adapter or monitor
26xx	XT/370
27xx	AT/370
28xx	3278/79 emulator adapter
29xx	IBM color/graphics printer
30xx	Local area network adapter
31xx	Alt. local area network adapter
32xx	Reserved
33xx	Compact printer
34xx	Reserved
35xx	Reserved
36xx	IEEE 488 (GPIB) adapter
37xx	Reserved
38xx	Data acquisition adapter
39xx	Professional graphics display
71xx	Voice commun. adapter
73xx	VGA adapter
85xx	IBM expanded memory adapter
86xx	Alternate input (painting device)
89xx	Music feature adapter
100xx	Multipratacal adapter
104xx	ESDI fixed disk

game is a good choice. If you have a color graphics and monochrome display connected to the computer, you can use the MODE command to switch between them. Type MODE MONO to switch to the monochrome monitor; MODE CO80 to switch to the color monitor. See the instructions in the DOS manual for more information.

Testing System Configuration

The best way to test the system configuration is with a utility (such as those supplied with the Norton Utilities). You can test some configurations with DOS; specifically, the amount of RAM that you have installed. To conduct the test, type: **CHKDSK**

and press Enter. On the screen you'll see the amount of RAM you have installed, along with information about the disk in Drive A:. The amount of RAM, in bytes, should equal the amount of RAM chips you have installed. You can convert bytes to kilobytes by dividing the number shown by 1,024. Therefore, a total memory of 655,360 bytes equals 640K bytes. The other number, indicating bytes free, is the memory left over after DOS has loaded and found its niche in the computer.

Note that the CHKDSK test shows the amount of memory you have installed, based on the DIP switch settings you have made, or the parameters you have indicated when running the setup program. If the switch settings or setup are wrong, the computer may indicate less memory than you have actually installed.

Interrupt Conflict

If one or more add-in boards do not function as they should, it could be that the interrupt settings of the boards (and possibly on the motherboard itself) are set incorrectly. The PC uses interrupts to allow things like keyboards, mice, and modems to "catch the attention" of the microprocessor. If two add-ins try to use the same interrupt, a conflict can result.

For your reference, Tables 4-2 and 4-3 show the interrupts commonly used in the XT and AT, respectively. You will need to refer to the manuals that accompanied your motherboard and add-in cards to ascertain what interrupts are being used, and how to change them.

Burn-in Test

If your computer has passed all of the above tests, you can pat yourself on the shoulder for a job well done. One last test remains before you call it a complete

Table 4-5. Frequently Encountered Error Codes

Code	Meaning
10x	System board
16x	System options not set
163	Time and date not set
164	Bad system memory configuration
20x	Memory problem
30x	Keyboard fault
401	Monochrome display fault
432	Parallel printer fault
50	Color/graphics display fault
601	Floppy drive fault
17xx	Hard drive fault
2401	Enhanced graphics display fault
2501	Enhanced graphics

success, however. That's the burn-in test. Leave the computer on for at least 24 hours, preferably when you or someone else is home to watch it. If any part of the computer is going to fail, odds are that it will do so within the burn-in period. The longer the burn-in period (one day minimum to a practical maximum of five or six days), the more you can be assured that your computer will continue to work for you.

During the burn-in, turn down the brightness and/or contrast on the monitor. This prevents the screen image from etching into the phosphor of the monitor. Periodically turn up the contrast and brightness and repeat the tests outlined above.

Testing Peripherals

Peripherals and expansion boards such as hard disk drives, clock boards, I/O boards, and other items were not installed in the previous section, and were not tested in this one. This approach is favored because by limiting the equipment you initially install in the computer, you limit the things that can go wrong.

Once the computer checks out, and you feel confident that everything works, you can begin adding more add-on cards and peripherals. With each expansion board or peripheral, turn the machine on and run it through its paces. If the computer suddenly stops working after you have installed a board, you can be fairly assured that the cause lies in it, and not the computer itself.

Easy Expansion

Expansion boards are designed so you can easily plug extra power into your computer.



Now that your IBM PC compatible computer is assembled and tested, what do you have? A great computer, right? Well, almost. What you have is the beginning of a great computer. Few computers are complete entities — all-in-one miracle boxes ready to plug into the wall and start chomping data. The needs of every computer user is different, so the majority of machines sold today are designed as foundations — firm earth on which to build bigger and better systems.

This feature, known as expandability, allows you to create a custom-designed system out of ready-made and easily purchased building blocks. Each building block has its own purpose, and adds to the power and versatility of the computer in one way or another. The ingredients — computer and building blocks — are more or less the same; the recipe is different. The result: A computer fine-tuned to the needs of the user.

The building blocks we speak of are expansion boards. These boards (also called cards), plug into the computer in any one of the eight expansion slots. A wide-variety of expansion boards are available for the IBM PC. Your do-it-yourself clone can enjoy most, if not all, of these power-building boards, too. Expansion boards for the basic operation of the computer, which include floppy disk controller cards and display cards, are covered in the "PC Basics" section.

Memory Expansion

The most important ingredient in souping up the power of your PC compatible is increasing the amount of RAM available. There is no rule of thumb for determining the amount of RAM you should have in your computer; it all depends on

the application and how heavily you use the computer.

The best way to determine the amount of memory you require is to consider the software you run. A number of the latest programs, like Windows 3.0, WordPerfect, and Excel, gobble up memory.

The design of your PC clone makes adding more memory a relatively painless operation. If the motherboard isn't already full (some memory sockets are still empty), you simply pop additional chips into a row or two of sockets. XT motherboards can be filled with up to 640K, most 80286 boards have room for 1 or 2 megabytes on board, and many 80386 and 80486 motherboards can accept 4, 8, and even 16 megabytes of RAM. You do not need (and usually can't use) a memory expansion board to increase the RAM in your clone to 640K. Most are designed for use with the older IBM PC, XT, and clones, and are not meant for do-it-yourself PC compatibles with 640K motherboards. If you use a combo, or multi-function, board in your computer, leave its RAM sockets empty (unless otherwise instructed by the manufacturer).

Co-processor Boards

The two elements of a computer's microprocessor that determine its power: Its architecture, or the number of bits it can digest at one time, and its clock speed, the rate at which the microprocessor works. The higher the number of bits,

the faster the number crunching. That's one reason why the AT, which has a true 16 bit microprocessor, is faster than the XT (and clones), which has an 8 bit microprocessor.

The PC, and non-turbo clones, have a clock speed of 4.7 MHz, 4.7 million cycles per second. The newest models of the AT are about twice that, and a number of ATs, 80386, and 80486 computers are even faster. The higher the clock speed, the faster each computational instruction is carried out.

If you've built an XT or AT, and it is too slow for your needs, or it can't run a piece of software that you want to use, you might be able to improve matters by adding a co-processor. Co-processors come in several forms. Some are single integrated circuits, such as the 8087 math chip; others are small circuit boards added over the motherboard; still others are full expansion boards that fit into one of the slots in the computer.

Basically, co-processors alter the personality of your computer by using a different microprocessor that either speeds up operations or allows the computer to run a different set of software (such as Apple II software or CP/M programs). Most co-processors available today are designed for the express purpose of speeding up the computer.

A favorite co-processor is the math chip, described in the previous section on Assembly. It is a single integrated circuit that snaps into place on the PC's motherboard. It goes into a socket intended specifically for the chip. The math co-processor is engineered to crunch numbers several times faster and more efficiently than the main microprocessor. It's important to remember, however, that many off-the-shelf programs, like

the older release 1A of 1-2-3, don't make use of the math co-processor.

Most co-processors are expansion boards you insert in the computer. The board plugs into an empty slot, and a cable or connector attaches to the main microprocessor socket. The microprocessor chip is removed and stored for safe keeping.

The processor on a "speedup" board for an XT may be any of several types: the NEC V-30, the Intel 8086, or the Intel 80286. The 80286 is the same chip used in the AT. The V-30 and 8086 chips provide a 10 to 50 percent speed increase; the 80286 can speed up the computer by several hundred percent (some even go as high as 600 percent). Note that not all clones can support extreme speed increases. A co-processor board with an 80286 chip operating at 8 or 10 MHz, for example, may outrun the other circuits in the computer. The circuits most likely to lag behind are the RAM chips. If you use a high-speed co-processor board, make sure the RAM chips are the fastest possible — 150 nanoseconds is the absolute slowest chips you can use; 100 nanoseconds is even better.

Hard Drives

Prices for hard disk drives have gone down as their capabilities have gone up. Drives with 40 megabytes and up are in demand these days, whether the drive is used by a single person, or shared in a local area network. If you have moderate to heavy data to track, a hard disk drive makes the job much easier. Read about installing hard disks in the next section "A How-To for Hard Drives."

Hard disk drives are either internal or external, although the external type is rare unless the drive has a very large capacity (over 350 megabytes). The typical internal hard disk drive fits in one of the drive compartments in the case. Like floppy disk drives, hard disks can be either full- or half height. Half-height 40 and 80 megabyte drives are common these days, and at affordable prices. The drive connects to the computer through a controller card. Mail-order prices for a 40Mb drive hover around the \$300 to \$350 range.

A number of hard disk drives and controller cards now come on a single board — the so-called hard-disk-drive-on-a-card. The storage limit of these drives has increased all the way up to 80 megabytes and beyond. Still 20Mb and 40Mb are more common. That's enough for most jobs. The best feature of the hard-

disk-on-a-card is that it leaves the drive compartment empty. You can now fill the compartment with a streaming tape backup unit, to make archival copies of the hard disk drive contents. The all-in-one concept also makes installing the drive easier. Since the drive and controller are packaged together, they are factory preset to one another. If you buy a hard disk and controller separately, you often have to configure them to match.

Checking for Quality

For years, a famous TV maker has used the slogan, "The quality goes in before the name goes on." An alarmingly large number of expansion board makers have taken the opposite view: "The profits come in before the nameplate falls off."

In our estimation, about 30 percent of the expansion boards available for the PC and PC clones are badly made, poorly designed "me too" products. The cheap boards are the most common in build-it-yourself kits and components. The parts are priced low, to attract a cost-conscious buyer. Nothing wrong with saving money, but make sure you get a product you can use and will last longer than the warranty period.

Fortunately, it's rather easy to spot poor manufacturing. To inspect a board (and this includes the motherboard), hold it by the edges only, and first look on its back side, the part that has no components on it. What you should see is a collection of bright silver solder joints, with perhaps a bit of the metal leads of the components on the other side peeking through. You shouldn't see a lot of wires coursing over the back side. These "patches" are signs of a hurried board design, or a design that proved faulty when the board was manufactured. Likewise, there should be no long component leads poking through the solder. The longer the leads, the more chance that some will bend and touch one another, causing a serious short circuit.

The best test is to see if the board works. You can't perform this test until you plug the board in, so do so before you buy it or immediately when you get home. You'll also spot design imperfections. Some imperfections are actually normal. Only a good, high-quality board overcomes them. For example, most all color graphics boards display flicker when scrolling text. The flicker is present in the original IBM board, and is duplicated in most clone boards. Most top-notch display boards, especially those that support the newer

enhanced graphics display mode, produce a flickerless screen.

Installing an Expansion Board

Expansion boards are designed so you can easily plug extra power in your computer, without requiring a service technician to solder wires or disassemble anything. Installing an expansion board isn't difficult, especially if it is one of the common types, such as multi-function or graphics. In addition to reading the instructions that came with the board, keep the following tips in mind.

Before You Start

Before you attempt to install an expansion board in your computer, make sure you have plenty of elbow room. Working in a cramped space simply invites trouble. Work only at a well-lit table, covered with a soft fabric.

If your case is the IBM PC style, loosen the chassis screws and slide off the top. If the case is the flip-top style, press the release catches on either side and lift up the top. The top should lock into position.

CAUTION: Before you remove or lift the cover, be sure that the power to the computer is off and the AC cord is unplugged. NEVER remove or install an expansion board while the computer is on. Doing so may damage the board and the computer.

Like the motherboard, expansion boards use delicate integrated circuits that can be damaged if subjected to static electricity. You carry a static charge wherever you go (even if the weather isn't dry), so before you take your computer apart and handle the expansion board, discharge the static from your body first. The best way is to touch the metal chassis of any grounded appliance, like an office copier. For extra protection, cover your work table with an antistatic mat instead of fabric. You can use the mat during regular use of the computer as well.

Setting the Switches

Most expansion boards need to be configured before you can install them. Almost all boards use one of two methods for changing their operating characteristics: miniature DIP switches or jumpers (some boards even have both). The DIP switches are the same kind found on the motherboard, and are set by throwing the switch on or off. Use the end of a blunt instrument such as a pencil lead or the tip of a ball-point pen (be

EXPANSION BOARDS

careful that no pencil graphite or ink gets on or in the switches). If you can, use a wood or plastic stylus. An orange stick from a manicuring set works fine. Jumpers are set by removing or moving jumper blocks. If the blocks are removed, keep them in a safe place in case you need them later. You can also reattach the block to just one of the jumper leads. Grasp the jumper block with a small pair of needle-nose pliers. In a pinch (forgive the pun), you can use a pair of surgical forceps or tweezers.

Set the switches and jumpers as indicated in the manual that accompanied the board. Depending on the type of board you have, you'll be:

- Setting the address of the parallel port(s). Your PC clone can support up to three parallel ports, and you usually indicate which address the port assumes by changing the DIP switches and jumpers.
- Setting the address of the serial port(s). Your PC clone can support up to two serial ports, and you usually indicate which address the port is to assume by changing the DIP switches and jumpers.
- Setting the memory. Since most all clone motherboards do not use the RAM installed on a multi-function expansion board (RAM, I/O ports, etc.), you will leave the memory sockets empty. You will also set the DIP switches or jumpers to OK on the add-on board.
- Setting the operation of the clock. The clock keeps the time and date in special memory, even when the computer is turned off. You can turn the clock on or off by adjusting the switches or jumpers.
- Setting the operation of the game port. The PC can support a game port, which accepts paddles or joysticks. The port can be turned on or off with the switches or jumpers.
- Setting the type and capacity of the hard disk. Unless previously set at the factory, the hard disk disk controller card must be told what kind of hard disk system it is controlling, and how large it is. You do this by adjusting DIP switches or jumpers.

Installing the Board

Once you've set things up properly, you can install your add-on in an empty expansion slot. With the PC clone, you can put just about any board in any slot, although if you are installing a co-processor, it should be located in slot 8 (the one closest to the microprocessor socket). The floppy disk controller card is most comfortable in slot 6 or 7, located near the drives.

To install the card, first remove the cut-out cover (in the back of the case) for the slot you want to use. Keep the screw for later. Handle the board by the edges, making sure you don't touch the components or the narrow strips of metal on the edge connector. When inserting the board, be careful to line up the edge connectors with the expansion slot. If the expansion slot has never held a board before, the contacts inside it may be stiff, and extra pressure may be required to seat the board inside the connector. Though you may need to press down firmly to get the board in place, never force it. If you are having trouble inserting the board, look to see if there are any obstructions, then try again.

If the board is full length, be sure to slide it through the plastic card guides located in the front of the case. The card guides hold the board firmly in place, and, though they are not absolutely necessary, they provide an extra measure of protection against bending and breakage.

Once the board is in place, press down firmly but gently, applying even pressure across the rear portion of the card. This seats the card in the expansion slot. Position the board's mounting bracket over the rear of the case, and line up the screw holes. Use the screw you previously removed to secure the bracket to the case.

When exchanging one type of display adapter to another (mono for color, or vice versa), or adding an additional display adapter card, set DIP switches five and six on the motherboard on an XT.

Routing the Cables

Many expansion boards have extra cables. To keep things neat and clean, route the cables carefully. A number of multi-function boards have separate cables for serial and parallel ports. These cables sometimes terminate in separate mounting brackets. If you have a free slot or two, attach these brackets in place of the cut-out covers. If the slots are used up, you'll have to let the cables dangle from the back of the machine. When attaching the cables to the board, make sure you observe proper polarity. With most boards, the cable and board connectors are polarized, so they fit in one direction only. But don't take chances. Refer to the manual that came with the board for specific instructions.

Inspection and Testing

Before you close the computer, inspect your handiwork and carefully search for potential problems.

- Is the board snugly in place in the expansion slot? It should be.
- Are all the cables firmly attached? Make sure they are.
- Are any brackets or other metal objects touching the expansion boards or motherboard? If so, correct the problem now.
- Are any expansion boards touching one another (a problem typical when installing all-in-one hard disk cards)? If this is so, relocate the boards to see if you can provide more space. If necessary, use a thick sheet of plastic as an insulator between two boards.

Close the computer, plug it back in, and turn it on. On power up, the ROM BIOS chip will test the RAM memory and expansion boards. If there is a problem in an expansion board, the computer may not start and an error message will appear on the screen. Sometimes, the error message will appear but the computer will still operate, and in a few cases, the computer may never start and the screen will remain blank. If there is a problem, immediately turn the computer off, open the case, and double-check your work.

With some boards, you may need to run a software utility to engage the board in the computer system. When installing a board in an AT, you must run the SETUP utility to tell the computer that you have made changes.

Even if everything seems to be running smoothly, you may want to run some type of diagnostic program. The diagnostics will check the memory, serial ports, and so forth. Bear in mind that the diagnostic program may not test everything. For example, the standard diagnostic utility supplied with the IBM PC (and works on many clones), tests only the parallel port assigned the LPT1 address. Other parallel ports are left untested, so you'll have to connect a printer or some other peripheral to see if they work properly.

Similar restrictions apply when installing monochrome graphics boards. In fact, with some boards, running the IBM diagnostic programs may even cause damage. Be sure to read the instructions packed with your board to see if this applies.

The final test is making sure all your software works properly. Watch for any inconsistencies and changes over the way the program used to work. Look for sluggish operation or errors you've never encountered before. If you find an operational problem, see if the manual included with the board has a troubleshooting section.

A How-to for Hard Drives

Installing a hard disk drive is the first task.

Learning how to use it is the second.



This section details the basics of installing a hard disk drive in your IBM PC compatible computer. Plus useful tips and tricks of using a hard drive. You'll learn about the basic organization of hard drives, how to create directories, moving to directories, suggested directory systems, and more.

Instead of data capacities in the kilobytes, hard disk drives store data in the megabytes. Common hard disk drive capacities for the PC and clones are 20, 30, 40, and 80 megabyte (40 and 80 megabyte are the most popular).

Prior to installing any hard disk, you should thoroughly read the instruction manual that came with it. Because of the disparity among hard disk drive interfaces and operational procedures, this section covers the preliminaries only. Avoid using the standard MS-DOS hard disk utility programs (such as RESTORE) unless told to do so by the hard disk drive manufacturer. Some DOS utilities do not work with certain drives, particularly the hard-disks-on-a-card, and you run the risk of losing some or all of the data stored on the drive.

Preparing the Drive

Most hard disk subsystems contain the following: hard disk drive unit; hard disk drive controller card; signal and control cables.

The all-in-one hard disk drive cards combine the drive unit, controller, and cables in one board package. The board fits any empty slot in the computer. Due to its thickness, most hard-disk-drives-on-a-card cover up more than one slot, so be sure to leave ample room.

If you purchased the hard disk drive and controller separately, your task is a little more complex than if you pur-

chased the pair as a kit. If the drive and controller are separate, you will probably have to perform a "low-level" format (also called hard format, drive initialization, primary format, initial format, or physical format). The controller card should come with instructions and a software disk on how to perform the low-level format. You need do this format once only. In any case, forget about it for now until after the drive is installed.

You will also need to tell the controller card the size (capacity) and type of drive you are using. You set a series of DIP switches or jumpers accordingly. You identify the drive in any of three ways:

Drive identifier letter. Letters of the alphabet are used by some drives to identify their capacity and type. The instruction manual packed with the controller card shows how to set the switches or jumpers for that particular drive.

Drive make and model. You can identify the drive by its make and model. A table in the controller card manual shows how to set the switches/jumpers to match your unit.

Drive electronics. The controller is mainly interested in the overall capacity of the drive, the number of data tracks (called cylinders), and the number of heads. If you know these things (by looking at the information sheet accompanying the drive unit), you should be able to properly set the DIP switches and jumpers on the controller card.

If the drive and controller came together, or as a kit, the switches and/or jumpers are probably already set for you. You need only to install the drive as explained in the next section. To avoid any possible trouble, ask your dealer to double-check the jumper/switch settings before you take the hard disk drive system home.

Installing the Drive

Once the controller has been configured, it's ready to be installed. Start first with mounting the drive in the empty drive compartment. If it is a half-height drive, mount it so that it fills the top of the compartment. Cover the bottom part of the compartment with a blank plastic bezel. The exact mounting procedure varies, depending on the design of the case and drive, but most use a solid bracket to secure the right side of the drive, and a removable bracket for the left side.

With the hardware supplied with the case or drive, attach the drive unit to the removable bracket. Do not over tighten the screws. Place the drive in the compartment, and set the bracket into its mating slots in the chassis. Finish the job by securing the right side of the drive to the right bracket (see Figure 6-1). Use the hardware provided.

Connect a cable from the power supply to the power connector on the hard disk. The power cable is the same kind used with the floppy drives. If the power supply has no extra cables, disconnect a cable from a floppy drive and attach the input of Y-adapter cable to it. Feed the outputs of the adapter to a floppy disk drive and to the hard disk drive.

Now install the hard disk controller card. Locate a blank slot as close to the

drive unit as possible. Slots 5 or 6 are good choices. Remove the blank cutout cover and save the screw. Attach the signal cables to the drive. When installing ST-506 and ESDI hard drives, one cable is smaller and contains 20 conductors; the other cable is larger and contains 34 conductors (SCSI hard drives have just one cable). Fit the cables into their respective connectors on the controller card. The connector and cable will have corresponding notches — keys — to prevent you from installing them backwards. If they don't, examine the instructions that came with the controller card for information on how to orient the cable. In many cases, the striped (colored) edge of the ribbon cable will fit closest to the notch in the connector on the controller card.

Gently slip the controller card into the slot, being careful not to dislodge the cables from their connectors. When the card is in place, tuck the cables along the side of the board and lead them over to the hard disk drive. DO NOT run the cables over or under the floppy disk drives. They may snag on the exposed moving parts. There is usually a small space for the cables between the disk drives and the power supply. Secure the controller card to the chassis by installing and tightening the mounting screw.

Connect the 20 and 34 conductor cables to the appropriate connectors on the hard disk drive. Note the orientation, as you did when attaching the cables to the controller card. If there is extra cable (and there usually will be), tuck the excess under the drive.

Remember that you DO NOT reset the DIP switches on the motherboard to reflect the addition of a hard disk drive. Switches seven and eight set the number of floppy disk drives only.

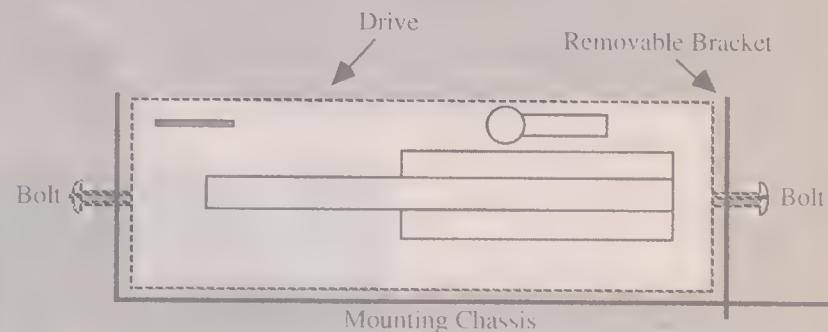
Formatting the Drive

If the drive is fresh from the factory, and has not been used before, it must be formatted and prepared for data. Depending on how your system was packaged, there are four tasks that need to be completed before you can use the drive:

- Hard format.
- FDISK initialization.
- Soft format.
- Copy DOS files.

Before formatting and preparing the drive, you cannot access the hard disk drive, so don't even try. When the drive is ready for use, DOS will automatically assign it the next drive letter following the existing floppy drives. Thus, in a

FIGURE 3-1 Drive Mounting Detail



one-floppy system, the hard disk is assigned as Drive B; and in a two-floppy system, the hard disk is assigned as Drive C:.

To format the hard disk, start the computer in the usual way using your DOS disk (actually, you should be using a COPY of the DOS disk; keep the original in a safe place).

Again, note that some drives and controller cards do not use the programs and procedures outlined below. Before formatting and preparing your hard disk drive, read through the instruction manual first. The manufacturer may provide another formatting program for you to use.

Hard Format

If the drive and controller card are not packaged together, you will need to mate the two with a low level, hard format, as explained earlier. The controller will come with suitable software for this purpose, or will tell you how to accomplish this using the DOS DEBUG program. Follow the instructions carefully and you won't have any trouble. The computer does most of the work for you. Hard formatting can take a long time, especially if the drive-capacity is large, so plan on going to lunch or a long coffee break. Figure 20 minutes for 10Mb.

FDISK Initialization

With most all drives, you use the DOS FDISK utility to "partition" the drive and to ready it for MS-DOS and programs. The FDISK utility is on your master DOS disk. To invoke the utility, type:

FDISK

and press the Enter key. The utility will ask a series of questions. Unless you

want to do otherwise, just press the Enter key at each question to select the default setting. Among other things, you tell the FDISK utility that you want to use the entire hard disk to hold MS-DOS programs (as opposed to part MS-DOS, part CP/M-86, and part Unix).

Alternatively, you can ask FDISK to set aside portions of the disk as "logical drives." This requires you to create extended partitions following the prompts provided by FDISK. You should refer to the DOS manual if you want to set up your hard disk using logical drives.

The utility will now prepare the hard disk for use. This preparation won't take long — generally five to 10 minutes for most drives. When FDISK is finished, restart the computer (you may have to switch it off and turn it back on again).

This time, when the computer is booted up, DOS will recognize the presence of the hard disk. You can test this by entering the drive assignment for the hard disk unit (usually C:). DOS will display the familiar B> or C> prompts, signaling you that it recognizes the drive. The drive has not been fully formatted, however, so it isn't ready for use. Do not call a directory; you won't get one.

Soft Format

You format the hard disk drive just the same as you format a blank floppy disk. With the computer on and booted up, type:

FORMAT C:/S

and press Enter. This assumes a two-floppy computer system, with the hard disk assigned as drive C:. If you have a one-floppy system, replace the C: identifier with B: . The /S option automatically places the DOS COMMAND and hidden boot files on the hard disk. This

way, the computer can be started from the hard disk, instead of the A: floppy drive.

The format procedure formats the drive and finds all the bad spots on the disk drive surface. These bad spots (sectors) are identified and locked out, so DOS won't try to place data over them. When the format is finished, DOS will display the amount of bytes on the disk that represent bad sectors. It should not be more than five percent of the disk's capacity.

Once the disk has been formatted, there usually isn't any reason to do it again. In fact, formatting the disk at some later date will erase its contents. If you must reformat your hard disk drive, for whatever reason, archive as many files as you can onto floppy disk or streaming tape. Reformat the disk following the procedure above, and copy the files back onto the disk.

Copy DOS Files

You now have a bootable system on the hard disk. Complete the disk by transferring all of the contents of the DOS disk to the hard disk. With the DOS disk in drive A:, type:

COPY A:.* C:

and press Enter. This assumes a two-floppy computer system, with the hard disk assigned as drive C:. If you have a one-floppy system, replace the C: identifier with B:.

One by one, all of the files on the A: drive will be copied to the hard drive. You may wish to go back and DElete DOS files on the hard disk drive that you don't want. Until you get to know DOS, however, best leave them there.

Using DOS 4.0

If you are installing DOS 4.0 on your hard disk, consider using the automatic installation program that comes with the package. If the hard drive is not already set up, the installation program will automatically run the FDISK program, where you can partition the drive as you like. The entire process of high level formatting and copying files to the hard drive are done for you.



Using a Hard Disk Drive

hard disk, has at least one directory. This main directory is called the root. If you don't use any other directories on your disk, the files you copy and create on your computer will be located in the root directory.

Floppy disks are often limited to just the root directory, because they hold a relatively small number of files. The standard 360K PC floppy disk can hold no more than 112 files, regardless of the physical size of the files. This limitation is based on the directory structure of the disk. Higher capacity floppy disks can contain more files, but again, the maximum number of files is dependent on the directory capacity.

And as with floppy disks, the root directory of a hard disk is engineered to accept only so many files before it fills up. The average 20 megabyte hard drive has room in the root directory for only 512 files.

This is really where directories (also called "subdirectories") come in. A directory is a separate repository of files that branches off the root. You can most easily imagine the structure of directories on a hard disk by thinking of the shape of a tree. The root and trunk of the tree is the like the main directory on a computer disk. Growing from the trunk are limbs. These are the various subdirectories. And from these limbs there may be additional branches, perhaps splitting off many times before ending up at the leaves. The leaves are the "data files" in our organic analogy.

As with the tree, a root directory on a computer disk can branch off into many independent directories. From these directories there can be additional directories. For practical purposes, few hard disks use more than two levels of directories.

The organization and names of the directories on your hard disk are completely up to you. Directory names are limited to the same naming conventions as files — eight characters plus an optional three character extension (the extension is rarely used).

If you've just formatted the hard drive, it contains no files or subdirectories, and is like a blank canvas waiting for your paint. At this point, you should take a few moments and decide what directories you want on your disk, and how they

Every disk, whether it's a floppy or

will be arranged.

Making a Directory

Directories can be created anywhere on a disk, from the root directory or from another directory. The root directory is the most common spot to create a new directory. We'll use that for our example.

To create a new directory, start your computer in the normal fashion. If your hard disk is properly installed and set up, you should see the **C>** prompt on the screen (you may need to press the Enter key a few times as the computer asks for the current time and date). At the **C>** prompt type **MKDIR subdir**. In place of "subdir" type the name of the directory you want to create. The **MKDIR** command is short for "make directory." As a shortcut, you can use the short-form of the **MKDIR** command: **MD**. Type **MD subdir**.

Moving to a Directory

The directory you created in the previous section now resides on your disk, but you have not yet "moved" to it. When your computer starts, the root directory of your disk is activated, or made current. Commands you type at the keyboard affect the files within the root directory. The current directory is often referred to as the "default." To work on files in another directory, the easiest way is to make it the new default, and that requires that you to change the directory, using the **CHDIR** (for "change directory") command.

At the DOS prompt, type **CHDIR subdir**. As before, exchange **subdir** for the actual name of the directory that you created. Alternatively, you can use the short-form of the **CHDIR** command, which is **CD**. As you'll be using the change directory command often, it's a good idea to get used to the short-form, as it cuts down on your typing.

Subdirectories behave just like the root directory. Typing **DIR** at the DOS prompt displays a directory of files. As you just created the directory, it will be empty, except for two entries, shown only as a single and double period.

Note that when viewing a disk directory with the **DIR** command, beside the names of directories is the designation **<DIR>**. This lets you know that the name is for a directory, not a file.

Before you copy or create files in a directory, you should make sure you're in the right one. Ask for a **DIR**ectory, and note the directory name that appears.

Or, type **CD** (with no directory name). Your computer will respond with the name of the current directory. You can also tell DOS to always display the current directory by typing **PROMPT \$p\$\g** at the DOS prompt. For ease of use, add this command to the **AUTOEXEC.BAT** file in the root directory. Your computer will automatically run the **AUTOEXEC.BAT** file whenever it starts.

To move back to the root directory, type **CD **. The backslash without a directory name after it means "root directory." If you have other directories already created on your disk, you can instantly activate them by typing their name after the backslash, as in **CD \otherdir**. Substitute the directory you want for "otherdir."

If you'd like to move up from one subdirectory to a higher level, regardless of the name of the directory, you can use the **CD ..** command. This command moves you from the current directory to the directory just above it — from **Subdir_B** to **Dir_B**, for example, or from **Dir_B** to the root directory. The **CD ..** command is helpful if you don't know the full path of the directory, or if you just want to quickly move between directory levels.

Clearing a Path

Your computer keeps track of all directories (root and directories) by path names. A path is the course from the root directory to the destination directory. That path may have any number of intermediate directories. Path names may look complex, but they really are quite simple. Each directory name in the path is separated by a backslash. Suppose, for example, that you want to move to directory that is located under yet another directory. To instantly activate (and therefore make current) the **Subdir2** directory, type **CD \Subdir1\Subdir2**.

You can type this command at any spot on the hard disk, regardless of the directory you're currently in. The first backslash in the path name means "start from the root directory." Because you included this backslash, the computer interprets this command as an absolute path name.

Leaving off the beginning backslash causes the computer to consider the command a relative path name. Your computer will assume you want to move to a directory path starting at the current directory. If the directory you want to move to isn't under the current directory,

you will get an error.

Copy Files Between Directories

Moving to a different directory on your hard disk lets you easily look at and access files in that directory. You will most often use the **CD** command to maneuver around your hard disk so you can use various programs. Another task that is often required is copying files between directories. The procedure is similar to copying files from one disk to another, except that the files are duplicated between directories on the same disk.

You can copy files no matter where you are on the disk, but the task is easiest when you are in either the source or target directories. The source is the directory that contains the files you want to copy; the target is the directory where the files will be copied to. To copy the files, use the full path name to indicate the source and/or the target.

For example, suppose you're currently in the **COMM** directory, which you use when talking to other computers via a communications program. You want to copy a file named **MYFILE.TXT**, which resides in the **WP50** (for WordPerfect 5.0) directory. From the **COMM** directory, type **COPY \WP50\MYFILE.TXT**.

DOS will automatically fetch the file in the indicated source directory, and copy it in the current directory. Because you didn't stipulate another name for the copy, DOS assumes you want to keep the filename as **MYFILE.TXT**.

If you are already in the **WP50** directory, and want to copy the file to the **COMM** directory, you'd enter **COPY MYFILE.TXT \COMM\NEWFILE.TXT**. The first portion of the **COPY** command indicates the name for the source file, which currently resides in the default directory. The second portion indicates the name of the copy, which is to be placed in the **COMM** directory. This example specifies a name of **NEWFILE.TXT** for the copy, but you can keep the old name or choose any other name you like.

Extending this example, you can copy files from one directory to another, even if you aren't in the source or target directory. Merely indicate the full path for both the source and the target files, as in **COPY \WP50\MYFILE.TXT \COMM\MYFILE.TXT**.

If you need to copy a file to a directory on another disk, provide the drive letter in front of the path. You will often use cross-disk copying when transferring files between a floppy disk and hard disk.

Note that some computer programs are copy-protected, and may not allow you to transfer them to a hard disk. Some copy-protection schemes (such as the one used with Lotus 1-2-3 release 1A) are based on the key-disk system. The program can be copied to the hard disk, but the copy is not an exact duplicate of the original on the distribution diskette. When you run the copy on the hard disk, the software knows it is not an original, and you are asked to temporarily insert the distribution diskette into the floppy disk drive. The program then checks to be sure that the original is a good copy, and you are allowed to proceed.

Other copy protection systems do not permit the program to be transferred to another disk, either floppy or hard. The resulting copy, if it can be made, will not run. However, copying utilities are available that let you get around this limitation. One such utility is Copy II PC, from Central Point Software. You use the utility to install a copy of your applications program on the hard disk drive. Additionally, some graphics programs software comes with their own hard disk installation program. You can use the program to install and remove copies of the software from work disks and hard disk drives.

Deleting Directories

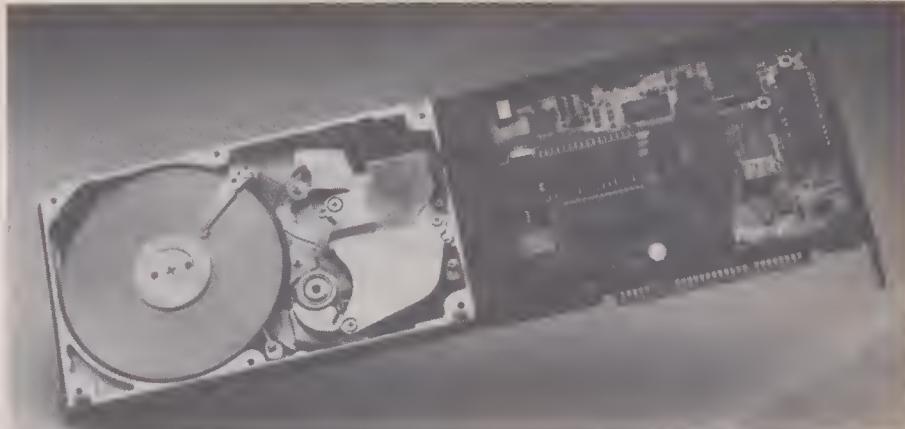
Sooner or later, you'll want to delete a directory from your hard disk. Perhaps you no longer need the files contained within the directory, or you want to move the files to another location. Follow these steps to delete a directory:

1. Delete ALL the files in the directory. Be absolutely sure you are in the proper directory, or you could delete files you want to keep.
2. Move to the next higher directory (use the CD .. or CD \ commands).
3. Type RMDIR subdir (or RD subdir). Substitute subdir with the name of the directory you want to delete. If you are in the root directory, the safest way to delete the proper subdirectory is to provide the full path name.

Note that DOS will not let you delete a directory that contains files. You can delete any directory on your disk except the root directory. That one has to stay.

Managing Your Hard Drive

So far, we've discussed the basics of using a hard drive in everyday applications, specifically, creating and using directories. If you're like most computer users,



Hardcard 40: A 40 megabyte hard disk expansion board, shown with exposed head disk assembly. Manufactured by Plus Development Corporation.

this will comprise the bulk of work you'll do with your hard drive. The rest will be transparent to you as you work on the various programs you have installed on your drive.

While hard disk drives are generally hearty beasts, they are not infallible, and have been known to lose data. In fact, such data loss is inevitable. Sooner or later, one or more files on your hard disk will become inaccessible because of some glitch. While the glitches can be reduced with careful use of the hard disk, it is impossible to eliminate them altogether. This is where hard disk utility programs come in.

- Hard disk utilities come in many flavors. The most popular are:
- Back up utilities
- DOS shells
- File/disk recovery
- Hard disk maintenance

Several hard disk utility programs are reviewed elsewhere in this issue, but let's take a moment to review their application and usefulness here.

Back Up Utilities

DOS comes with two programs — BACKUP and RESTORE — for making archival copies of your hard disk files. BACKUP samples the contents of your drive and compresses the files onto a series of diskettes. The BACKUP program is designed to be used every day or at least every week, so that you have an up-to-date record of the files on your hard disk. RESTORE is used only when one or more files on the hard disk become corrupted. RESTORE fetches the desired files from the storage diskettes and re-copies them to the hard drive.

BACKUP and RESTORE do an acceptable job, but they tend to be slow and lack many advanced features. A back up

utility, such as Fastback Plus, duplicates the function of the DOS BACKUP and RESTORE programs, plus adds speed, versatility, and convenience. Many hard disk backup programs also let you archive files to another hard drive or to streaming tape.

To be effective, you must back up your hard disk regularly. Ideally, you should back up all the files on the drive once a week. Use a separate set of storage diskettes to hold three week's worth of backups; that is, use one set for Week 1, another set for Week 2, and a third set for Week 3. At Week 4, use the first set of storage diskettes, and rotate the others in turn. Full backups can consume a dozen or more diskettes, but the cost of diskettes is trivial compared to the pain and agony of lost files.

In addition, you should make an "incremental" backup every day that you use the computer. The incremental backup archives only those files you have created or edited since the last backup. For most users, this will require only a single diskette, possibly two. As with the weekly backups, use a separate diskette for each day. Label the diskettes Monday, Tuesday, Wednesday, and so forth. Re-use the diskettes the following week.

DOS Shells

A DOS shell is a utility that makes using PC/MS-DOS easier. For hard disk users this means easier access to files that have been placed into directories. A DOS shell like PC Tools Deluxe provides you with a "tree" of the directories on your hard disk, and all the files contained in any given directory. You can move, copy, delete files, as well as run programs, by selecting commands from the keyboard (PC Tools Deluxe also sup-

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ports a mouse).

Even if you are an experienced DOS user, you may find a shell program speeds up repetitive tasks. You may want to select only 50 files out of a directory that contains 100. A shell program lets you "point-and-shoot" at the files you want to copy, relieving you of having to enter their names one at a time.

DOS 4.0 comes with its own shell, which you may use if you like. It is basically a custom menuing program where you can tailor the screen choices to your specific needs.

File/Disk Recovery

The three top selling utility programs share one trait in common: they are all designed to recover lost or damaged files and disks. Although PC Tools Deluxe, Norton Utilities, and Mace Utilities attack the problems of file and disk recovery differently, they all promise the same results: bring a dead file or disk back to life. Of course, none of these programs are fool-proof 100 percent of the time, but the more you use your hard disk, the more you'll need one of these software packages.

At the most basic level, file recovery retrieves files you have accidentally erased, for example, using the DOS ERASE or DELETE commands. DOS doesn't trash the whole file, but merely deletes the file's entry in the disk's directory. A file recovery utility re-instantiates the directory entry. An erased file cannot be retrieved intact forever. The more a hard disk is used, the more chance that all or portions of the erased file will be overwritten with new data.

File and disk recovery is sometimes necessary due to accidental data loss. This data loss can naturally occur as a hard drive gets older: in time, all hard drives drift out of alignment, and loose various bits of data because of normal wear and tear. Too, data loss can be caused by a "head crash," when the read/write heads in the drive contact the delicate surface of the spinning magnetic platters. With careful recovery techniques, it is sometimes possible to reclaim files that may otherwise be lost to a hard disk showing its age or accidental head crash.

Hard Disk Maintenance

Hard disk maintenance utilities are designed to keep your hard disk in top working order. One hard disk maintenance procedure often performed is "file de-fragmentation." In normal use, the



Seagate ST325A: A 21.4 Mb formatted, 3.5-inch, low profile hard disk drive, featuring a 45 msec. access time, an embedded AT interface and a power consumption of two watts.

segments of individual files become scattered over the surface of a hard disk. This is due to the way DOS deletes files. If a file in the middle of the disk is erased, its space is cleared for another file you may create at a later date. If that file is too big to fit the emptied space, DOS will place as much of the file there, then record the rest someplace else. Over time, this fragmentation can become severe, eventually degrading the performance of the drive by a noticeable degree.

File de-fragmenters scan a hard disk looking for fragmented files, and re-record them in contiguous blocks on the drive. For the most part, file de-fragmenting programs are safe and don't pose a serious data hazard, but you should be sure to read the directions that came with the program carefully. Problems can occur if you attempt to stop the de-fragmenting process early, or if you attempt to de-fragment a hard drive while an incompatible disk cache is active in your computer's memory.

A more complex form of hard disk maintenance is provided by programs like SpinRite and Disk Technician Advanced. Both of these programs scan a hard disk and look for possible problems, such as "weak" sectors and misalignment. Both programs can also rejuvenate the low-level formatting of your hard drive, without requiring you to back up and restore the data on the disk. This low-level reformatting helps prevent the problems of data loss due to misalignment and wear and tear, and can help keep a hard disk in tip top shape.

Unfortunately, at this time neither SpinRite nor Disk Technician Advanced work with ESDI, SCSI, or RLL drives. Compatibility with these higher performance drives is said to be in the works for these two programs, but for the time being, they will work only with standard

ST-506 (using MFM recording) drives and controllers.

Hard Disk Do's and Don'ts

Keep these points in mind when using a hard drive:

If your hard disk drive does not include an automatic head parking feature (check the manual that came with the drive to be sure), always park the drive before turning off your computer. A suitable parking program should be included on a utilities disk supplied with your hard drive. One a parking utility is not included, check with your dealer for a recommendation of a program you can use.

Even if your computer offers automatic head parking, you may need to run a separate parking utility if you want to physically move your computer. Check the drive's manual for details.

When your computer is on the platters in the hard drive are constantly spinning (exception: when using a battery-powered portable with auto-shutdown mode). Avoid moving or jarring the computer, or a serious head crash could result.

Never take your hard disk apart, either to inspect it, clean it, or service it. Hard disks are sealed from outside contamination, and can only be opened in a "clean room" environment. There are no serviceable parts inside a hard disk drive.

Always back up your hard drive before installing new software. This included updates to the software already on your hard drive (upgrading from WordPerfect 5.0 to 5.1, for example), and especially when installing newer releases of DOS.

Never use the ERASE (*.*) (or DEL (*.*)) command unless you are ABSOLUTELY sure you want to delete all files in the current hard drive directory. Double-check that you are in the proper directory before issuing the command.

Use a commercially-available "anti-virus" program to guard against software virus, Trojan horse, and worm programs. Avoid using programs from unknown electronic bulletin board systems, or from unknown sources.

If your hard drive is divided into two or more logical drive partitions (one drive mechanism used as drive C: and D:, for instance), do not rely on archival backups made from one drive to the other. When archiving files use floppy diskettes, a streaming tape unit, or a physically separate hard drive for backup storage.

The Computer's Language

DOS is the operating system and the command language used to communicate with a PC.



Now that you've built a PC clone, you're ready to go to work. Pop a disk in the floppy drive, start up the machine, and you're ready to go. Or are you?

There's still one obstacle standing between you and your computer. It's called the disk operating system, and is the "command language" used to communicate with your computer. Sure, you can add auxiliary programs to your computer that help simplify the disk operating system (called DOS, rhymes with "toss"). But sooner or later, you're bound to come face to face with DOS, so you might as well learn how to use it, before you're forced into the relationship.

We'll leave the bare essentials of DOS to the little handbook that comes with your DOS disks. It'll get you up and running so you can start programs, copy files, and do the basic stuff. If you haven't read it before you can return to the "How-to for Hard Disks" section to learn more about managing a hard disk, creating directories and subdirectories.

What we're more interested here is concentrating on the next level of DOS use, the subjects that turn you from a stumbling neophyte into a DOS ace. The topics covered in this section are designed to help you squeeze more power out of your home-built computer investment.

If you are absolutely brand new to computers, read the basic introduction to the disk operating system in the handbook that came with your DOS disks. If no handbook is available, purchase a DOS quick reference guide at your local book store. It will contain enough information to get you pointed in the right direction. Or, if you'd prefer, you can buy a more detailed book on DOS, in

which case this section will provide a convenient review.

Understanding CONFIG.SYS

Two special files are common to most every IBM PC or clone system in use, yet many people are unaware of their purpose, or importance. The CONFIG.SYS and AUTOEXEC.BAT user files let you customize your computer the way you want. The AUTOEXEC.BAT file automatically runs programs when the computer first starts, and the CONFIG.SYS configures your computer to your requirements.

Though these files and their contents may appear cryptic to the uninitiated, their application and construction are not that complicated. In this section, you'll learn the function of the CONFIG.SYS file; the following section details AUTOEXEC.BAT. You'll learn what these files are, what they do, how to create them, and how to use the customizing tools available to squeeze extra power from your computer.

About the CONFIG.SYS

CONFIG.SYS is a user file — that is, you create it, even though it's designed expressly for use by the computer. The file consists of nothing more than English-like commands, each one on a separate line. You can use your favorite word processor to generate the CONFIG.SYS file, but the word processing program must have the ability to save documents

in ASCII or DOS text format.

Alternatively, you can create CONFIG.SYS directly at the DOS prompt (if the files are simple and short enough) or use the EDLIN line editor that comes with DOS. All three methods are detailed at the end of this section.

The CONFIG.SYS file is most often found in hard disk-based computers, although you can use it with floppy disks, as well. Each time you start or reset your computer, it examines the contents of the CONFIG.SYS file, and follows whatever instructions are found. If the CONFIG.SYS file is not provided, the computer starts using its own defaults.

An Inside Look

The CONFIG.SYS file performs three main tasks. It lets you change operating defaults to new settings; it lets you install software "drivers" so you can operate alternate input devices (like a mouse or graphics tablet); it permits you to install many types of memory-resident (TSR) programs.

Of the three primary tasks of the CONFIG.SYS file, most people use it simply to change a few standard defaults (the basic defaults are shown in Table 7-1). These defaults include the maximum number of files that DOS can open at once, and the amount of memory that can be used as "mini-buffers," for use in speeding up some disk access.

The commands that change default values, and are used in a CONFIG.SYS file, are:

- Break=
- Buffers=
- Country=
- Driveparm=
- FCBs=
- Files=

Table 7-1.
CONFIG.SYS
Command Defaults

There are the defaults for the CONFIG.SYS commands followed by their defaults:

Break Off
Buffers 15 (typical; varies with DOS version, amount of memory, and drive capacity)
Country 001
 (USA; same as Canada)
Driveparm None
FCBs 4,4
Files 8
Lastdrive E (single-user); N (network)
Shell \COMMAND.COM

- **Lastdrive=**
- **Shell=**

Most people use only the **Buffers=** and **Files=** commands. In all cases, you enter a specific value after the command, such as **Buffers=40**, or **Lastdrive=E**. We'll run through the use of these commands in a bit.

Note that when used in a CONFIG.SYS file, the capitalization of these commands doesn't matter. You can enter **FILES=**, **files=**, **Files=**, or any other combination of upper and lower case. Proper spelling, however, does count, so be sure you spell the commands properly. For instance, be careful to type "**Files=**" instead of "**Flies=**." While "**Flies=**" may mean something to you, it won't mean anything to your computer.

- The CONFIG.SYS commands perform the following functions. (Important note: not all commands are available with all versions of DOS; these commands are available in DOS 4.0 or later.)

- **Break** tells the computer how often you want to check the Ctrl-Break keys. Pressing Ctrl-Break indicates that you want to interrupt the computer and return control to you. With **break off** (**Break=off**), DOS only checks the Ctrl-Break keys during screen and keyboard input/output (as well as output to serial and parallel ports). With **Break on** (**Break=On**), DOS checks the Ctrl-Break keys more often, including during disk access.

- **Buffers** allocates portions of memory for speeding up disk- to-memory applications. The size of the portion is normally 528 bytes (larger in DOS 4.0 when

used with a high-capacity hard disk). The more buffers, up to a total of 255 (DOS 3.3 and later; or up to 10,000 buffers with DOS 4.0), the more RAM is reserved for computer use. There is a trade-off between increasing performance by adding more buffers, and consuming valuable RAM space that might otherwise be used by programs and data.

- The **Country** command establishes the format to use for the DOS date and time stamp. Countries are identified by number (you can obtain the number from the DOS manual). For example, the United States (default) is country code 001; Japan is country code 081. To change the country to Japan, you'd enter **Country=081**. Note: The **Country** command requires the use of a system file, **COUNTRY.SYS**, included with DOS.

- **Driveparm** changes certain parameters of a disk drive you have in your computer. You can set or reset the physical location of the drive, whether or not it's a hard drive, the format of the drive, and whether you want to use one drive to act as the source and destination of a disk copy. **Driveparm** requires the use of switches (such as **/d** for setting the drive letter) to set the parameters. The DOS manual (as well as most any good book on the subject) details these switches.

- **FCB** stands for file control block, and is a procedure by which DOS accesses files. One FCB is a portion of memory set aside by DOS for holding the name, location, structure, and length of a file. The **FCBs** command expects two numbers: the maximum number of memory blocks to use, and the number of blocks you want open at any one time. For example, **FCBs=4,1** sets a maximum of four blocks, with one open. Generally, you only need to use the **FCBs** command is when you are on a network or to enable older programs to work with newer versions of DOS.

- The **Files** command sets the number of files (more specifically, files that use "file handles") that DOS can open at once. Most programs require that several files be open at the same time; if your **Files** command is set below the minimum number of files that a program requires, trouble could occur. At a minimum, DOS requires that **Files** be set to a minimum of five, through 20 or 30 is more common to accommodate applications programs. The correct syntax to use is **Files=30**.

- **Lastdrive** sets the last drive available on your computer. DOS normally sets this to drive A (N if you're on a network). To

use the command, follow the letter of the last drive available, such as **Lastdrive=D**.

- The **Shell** command tells DOS the name of the command processor file. Normally, this is **COMMAND.COM**, but you can indicate another one. The most common use of the **Shell** command is to tell DOS where the **COMMAND.COM** file is located on a hard disk (in case it's not in the root directory). Merely provide the full path, such as **Shell= C:\DOS\COMMAND.COM** in the CONFIG.SYS file.

In addition to resetting defaults, the CONFIG.SYS file lets you load device drivers for use by your computer and applications programs. You can always tell a device driver by the ".SYS" file extension, such as **ANSI.SYS**. Some example of device drivers you might encounter:

- **RAMDISK.SYS** sets aside memory for use as a RAM disk
- **ANSI.SYS** sets your video terminal (monitor and keyboard) to VT-100 emulation.
- **MOUSE.SYS** allows you to use a mouse with applications programs that support it.

These drivers are loaded into your computer when it is first started or reset. To load a device driver into your computer, enter the driver using this syntax:

Device=driver.sys

Exchange the **driver.sys** for the actual name of the driver file you are using. Device drivers are specific to your computer and your applications software. When including a device driver in a CONFIG.SYS file, be sure to provide the actual driver file on the disk. You can use directory paths to indicate driver files that reside on other directories. For example,

Device=C:\WP51\DRIVERS\MOUSE.SYS

Loads the device driver file "MOUSE.SYS," which resides in the **WP51\DRIVERS** directory.

Most RAM-resident (or TSR) programs can be initially loaded using the **Install=** command in the CONFIG.SYS file. Example:

Install=Copysafe

Installs the "COPYSAFE" program at start-up or reset.

Creating and Editing CONFIG.SYS

- There are three ways to create or edit a CONFIG.SYS file.
- Write a new CONFIG.SYS directly at the DOS prompt.
- Write or edit a CONFIG.SYS using a word processor.

- Write or edit a CONFIG.SYS using the DOS EDLIN line editor.

Follow these steps to create a new CONFIG.SYS file directly at the DOS prompt. BE SURE that a CONFIG.SYS file doesn't exist, or you'll erase it.

1. At the DOS prompt and in the root directory (such as C:\), type:

COPY CON CONFIG.SYS
and press the Enter key.

2. Type a command (such as FILES=30), and press the Enter key. There should only be one command per line. You should press the Enter key after the last command as well.

3. When you're done writing the contents of the CONFIG.SYS file, press the F6 key, then press Enter.

If the file has been created properly, DOS should report "1 File(s) Copied." Remember that the new CONFIG.SYS parameters don't take effect until you reset your computer.

The DOS method doesn't allow you to edit an existing CONFIG.SYS file. If you need to create a large CONFIG.SYS file, or patch up one that already exists, you're best off using your word processor. The only requirement of the word processor is that it create ASCII (or DOS) text files. Formatted or binary files are not allowed, as your computer won't know how to read them. Most all popular word processors can create or save files in ASCII/text format.

As an example, to create a CONFIG.SYS file in WordPerfect 5.0 or 5.1:

1. Start WordPerfect
2. Enter the contents of the CONFIG.SYS file; one command per line. Be sure that you press the Enter key after each line (the last line should also be terminated with the Enter key).
3. Press Ctrl-F5 (Text In/Out).
4. Press T, then S, to choose the DOS Text and Save commands.
5. For the file name, type \CONFIG.SYS. This names the file "CONFIG.SYS" and automatically places it in the root directory. Press Enter when done.

You may now exit WordPerfect and restart your computer.

DOS's own line editor program, EDLIN, can also be used to create and edit the CONFIG.SYS file. Refer to the DOS manual for more information on using EDLIN.

Understanding AUTOEXEC.BAT

You may be a computer programmer and not know it. If you've ever created or edited a file called "AUTOEXEC.BAT" on your computer's hard disk, you were

programming the computer to follow your specific commands. The AUTOEXEC.BAT file is a special "batch" program that the computer runs each time it starts up — whether you've just turned the machine on, or reset it using the Ctrl-Alt-Del keys.

The AUTOEXEC.BAT file contains instructions to run other programs — like RAM-resident spell checkers or notebooks — and to select certain operating parameters that let you customize the computer to your tastes and requirements. The AUTOEXEC.BAT file is a time-saver, and is used to set up your computer the way you want it, without having to issue all the commands yourself.

If you'd like to take more control of your computer, learning about and using the AUTOEXEC.BAT feature is a great place to start. This section introduces you to AUTOEXEC.BAT, and explains how it's used and what it does. You'll also learn about several handy commands you can include in your AUTOEXEC.BAT file that takes some of the hassle out of using your computer.

What is AUTOEXEC.BAT?

The AUTOEXEC.BAT file is just an ordinary text file, which you can create right from the keyboard within DOS, or with your favorite word processor (more on this later). The file is composed of a series of commands, each on one line. With few exceptions, the commands used in an AUTOEXEC.BAT file are the same ones you can issue at the keyboard when using DOS manually. That is, if the AUTOEXEC.BAT file contains the command

CD \WORDPERFECT

the computer will automatically log into the \WORDPERFECT directory, just as if you typed the command from the keyboard yourself.

In addition to standard DOS commands, AUTOEXEC.BAT files can contain programming codes, as used in batch files. These programming codes make batch files "intelligent," performing actions based on user input, or the condition of your computer. Batch programming is a subject unto itself; we'll save it for the next section.

The AUTOEXEC.BAT file can be included on any disk you use to start your computer, either hard disk or floppy disk. However, the AUTOEXEC.BAT file is most often restricted to hard disk use. Once your computer starts and activates the AUTOEXEC.BAT file in the

current drive (drive C: if you're using a hard disk; drive A: if you're using a floppy disk), the operating parameters remain in effect until you reset them, or turn your computer off.

The AUTOEXEC.BAT file is always placed in the root directory of the disk. Otherwise the computer won't be able to find it, and the AUTOEXEC.BAT file will be ignored. As shown in the example in the next section, the AUTOEXEC.BAT file can be (and often is) used to automatically change directories on a hard disk, once the computer is started or reset. So even though your computer always starts out in the root directory, you can automatically move to any directory by including the appropriate command in your AUTOEXEC.BAT file. This is particularly handy if your computer is used by someone unfamiliar with DOS.

Whether you're using a hard disk or floppy disk, your computer does not require the use of an AUTOEXEC.BAT file. Should the computer start and not find an AUTOEXEC.BAT, it accesses the root directory of the current drive, and asks you to set the date and time. Here's an example of an AUTOEXEC.BAT file. It includes just a few programming codes. Most of the file is self-explanatory, but we'll take each command step-by-step.

```
ECHO OFF
PATH C:\CNDOS;
CD \BATCH
PROMPT $p$g
MENU
```

Remember that this is just a sample AUTOEXEC.BAT file. Yours will be different, depending on the organization of your hard disk, the programs you wish to run, and the special operating parameters you want to use.

Let's take a closer look at the example, and examine what each command does:

- ECHO OFF — This is the only batch programming code used in the AUTOEXEC.BAT file. It merely turns the screen display off while AUTOEXEC.BAT is executing. The ECHO OFF command prevents prompts and text from flashing on the screen.
- PATH C:\CNDOS; — PATH is a standard DOS command that tells your computer which disks and directories you want it to search when running programs. If you want to run a program that's in the \DOS directory, and not be required to move to that directory first, include the \DOS path in the PATH command. You can indicate a number of



paths to use; each one is separated by a semicolon. In DOS 3 or later, you can include a drive letter. The example establishes both the root and the \DOS directories for the PATH command (both are on C: drive).

- **CD \BATCH** — The CD \BATCH command changes the directory to \BATCH, which contains numerous batch programs for further automating the computer.
- **PROMPT \$p\$g** — The PROMPT \$p\$g command is a standard DOS function that changes the appearance of the DOS prompt. Normally, the DOS prompt appears as C:> (assuming you're using the C: drive). The same prompt appears regardless of the directory you're currently in. The PROMPT \$p\$g command changes the prompt to C:DIRNAME>, where DIRNAME is a name of the current directory. This approach makes using disk subdirectories easier, and helps prevent mistakes in copying and erasing files. Your AUTOEXEC.BAT file should contain the PROMPT \$p\$g command, if nothing else.
- **MENU** — The MENU command starts a batch file called MENU.BAT. This example shows how the AUTO EXEC.BAT file can run not only executable programs but also other batch files. The command for running a batch file must be at the end of AUTOEXEC.BAT. An example of the MENU.BAT file is provided later.

Note that the MENU command runs another batch file (the other commands shown in the example use features built into DOS). You can also run programs from the AUTOEXEC.BAT file. When you run a batch file from AUTO EXEC.BAT, it must be the last one in the command list (names of programs to run can be anywhere). Be sure that your computer can find the program or batch file you want to run, or it won't be able to

complete the commands you've given it.

If your computer can't find a program or batch file, it displays a "Bad command or file name" error message, just as it does when you enter a command at the keyboard that your computer doesn't understand. Because the commands in AUTOEXEC.BAT file are executed quickly, you can easily miss this message, and may not know that an error has occurred. You may think that your AUTOEXEC.BAT file has been properly completed, when in fact one or more of its commands were not carried out.

Creating a Batch File

Now that you know what a batch file is, and what it does, how do you go about creating one? There are two basic approaches: Create the AUTOEXEC.BAT file directly in DOS at the keyboard; create the AUTOEXEC.BAT file using a word processor.

Creating a file in DOS at the keyboard is best suited when the AUTO EXEC.BAT file is small — three or four lines at most. Larger files should be created using a word processor.

Follow these steps when creating AUTOEXEC.BAT file at the DOS prompt:

1. If you're not already there, move to the root directory of your drive by typing CD \
2. Type COPY CON AUTOEXEC.BAT and press the Enter key. This opens a file named "AUTOEXEC.BAT" and readies the computer to create the file directly from keyboard.
3. Enter each line of the AUTO EXEC.BAT file, and press Enter when done. Review the line before pressing Enter; you can make changes by backspacing. Once you press the Enter key, the line is recorded in the file.
5. After the last line, press Ctrl-Z, then Enter.

DOS should report that one file was copied. You can check the contents of the newly minted AUTOEXEC.BAT file by typing

TYPE AUTOEXEC.BAT

and pressing the Enter key. The text of the AUTOEXEC.BAT file should appear on the screen.

Before you create the AUTOEXEC.BAT file in this manner, be sure that one doesn't already exist. If the file is already present, creating one using this method will erase the old file.

If you have a word processor capable of formatting text in standard DOS or

ASCII format, you can use it to build an AUTOEXEC.BAT file. Start the program and write the file in the usual manner. Save the document (in the root directory of your hard disk), but be sure to select the DOS or ASCII file format. Your computer can't read an AUTOEXEC.BAT file that uses the special formatting of a word processor.

Running AUTOEXEC.BAT

After creating an AUTOEXEC.BAT program, you need to run it before the commands and parameters contained within it take effect. The most straightforward method is to restart your computer: press the Ctrl, Alt, and Del keys simultaneously. That should reset your computer. The AUTOEXEC.BAT file will automatically run after the computer has finished its start-up procedure (if your computer doesn't respond when you press these keys, turn it off, wait a few seconds, then turn it back on).

You can also activate the AUTO EXEC.BAT batch file by typing its name at the DOS prompt. Type

AUTOEXEC

and press Enter. DOS will execute the batch file in the same manner it does when the computer first starts.

After the AUTOEXEC.BAT file runs, take a moment to be sure that all your commands were carried out properly. If you spot an error, review the AUTO EXEC.BAT file and look for mistakes in syntax, commands that attempt to execute programs that the computer can't find, and so forth. Edit the AUTO EXEC.BAT file as required until it works satisfactorily.

After you create an AUTO EXEC.BAT file you'll want to store an extra copy of it on a back-up diskette, or in a reserved directory on your hard disk. Then, if anything happens to the original, you can easily replace it, rather than create it all over again from scratch. If nothing else, you should make a printout of your AUTOEXEC.BAT file for future reference.

Running other Batch Files

Your AUTOEXEC.BAT file can run not only executable programs, like Lotus 1-2-3 or WordPerfect, but also other batch files. The commands to run executable programs can be placed anywhere within the AUTOEXEC.BAT file — your computer runs these programs the moment the command is encountered.

Conversely, the command to run a batch file must be included at the very

end of the AUTOEXEC.BAT file. The PC is limited to executing one batch program at a time. As the AUTOEXEC.BAT file is really a batch program, it must finish before another one starts.

One type of batch program you may want to initiate with the AUTOEXEC.BAT file is a menu maker. The menu batch file contains programming codes and text that clear the screen, and display one or more menu choices. These menu choices let you run other programs on your hard disk.

Here is an example of a menu making batch file. This batch file contains just the menus; additional batch files are used to start each of the programs that are listed:

```
ECHO OFF
CLS
ECHO Master Menu
ECHO 1. Start WordStar
ECHO 2. Start WordPerfect
ECHO 3. Start Norton Util.
ECHO 4. Start Bitcom
ECHO 5. Start PC Tools
ECHO 6. Return to root directory
ECHO 7. Start Microsoft Works
ECHO 8. Start PC Desktop
ECHO 9. Start QuickBASIC
ECHO Q. Start Quicken
```

This batch program starts by momentarily turning the display off, then clearing it, with the CLS (CLear Screen) command. Then, each line of the menu is written on the screen with the ECHO command. The batch file then terminates, and the DOS prompt appears on the screen.

To start a program — say WordStar — type 1, then press the Enter key. That initiates the 1.BAT file, which (in this example) is:

- ECHO OFF
- CD \WS4
- WS
- ECHO OFF
- CD \BATCH
- MENU

This batch file turns the display off, changes the directory to \WS4 (where WordStar 4 resides), and starts the WordStar program (the WS command). Upon leaving WordStar, the batch file re-activates, turning the display off again, changing the directory to \BATCH (where all the batch files are kept), and displays the menu once more by initiating MENU.BAT.

Understanding FORMAT

Nothing causes more fear and dread than

Table 7-2 Diskette Capacities

Capacity	Size	Nomenclature	Tracks	Sectors per Track
160K	5 1/4"	Single-sided, double-density	40	8
180K	5 1/4"	Single-sided, double-density	40	9
320K	5 1/4"	Double-sided, double-density	80	8
360K*	5 1/4"	Double-sided, double-density	80	9
1.2MB*	5 1/4"	Double-sided, high-density	80	15 2nd
720*	3 1/2"	Double-sided, double-density	80	9 2nd
1.44MB*	3 1/2"	Double-sided, high-density	80	18

* Denotes standard diskette formats.

360K 5 1/4-inch standard on PC/XT and clones

1.2MB 5 1/4-inch standard on PC/AT and clones

720K and 1.44MB 3 1/2-inch standard on IBM PS/2 and clones

DOS's FORMAT command. This one command has been responsible for more than its fair share of disk mishaps, like erasing floppy disks you didn't mean to erase, or totally obliterating the contents of a hard disk drive.

Yet there's no real need to disdain the FORMAT command. While it can certainly be abused if applied carelessly, it is nevertheless one of the cornerstones to the power of DOS. The FORMAT command allows you to prepare new disks for data, and to even "wipe the slate clean" and re-use old disks to hold new information.

You may not think of the FORMAT command as hiding many secrets. Yet FORMAT doesn't reveal its true nature unless you force a closer look. Here, you'll learn about the power and flexibility of the FORMAT command, including how to use its various options such as making system or bootable disks, providing disk names, forcing a certain capacity, and more.

What FORMAT Does

The FORMAT command prepares — or "initializes" — a diskette or hard disk for data. Let's concentrate on floppy diskettes for the time being. If the diskette is brand new, formatting encodes the surface as a concentric ring of tracks and sectors. The segmentation allows data to be placed on the disk later on. If the diskette has been used already, the old information is completely replaced and a new set of tracks and sectors are recorded.

Formatting takes into account the size and type of the diskette. The arrangement of tracks and sectors on a 5 1/4-inch disk is formatted in a different manner as the tracks and sectors on a 3 1/2-inch disk. This affects the density of the disk-

ette, or the amount of data the formatted diskette can hold.

A particular size of diskette can be formatted in a number of ways, with varying degrees of density. For example, a 3 1/2- inch diskette can be formatted to hold either 720K bytes of data, or 1.44 megabytes of data, depending on how the tracks and sectors are layed out. See Table 7-2 for a run-down of disk sizes, and how they can be formatted in different capacities.

The FORMAT command is smart enough to detect the type of drive you are using, and automatically initializes the diskette accordingly. The FORMAT command assumes you want to format the diskette with the maximum capacity possible with that drive. For example, if you have a standard double-sided, double-density 5 1/4-inch drive, the maximum formatted capacity is 360K. A disk you format with this drive will normally hold 360K of data.

However, you can force a lower capacity by using an option "switch" along with the FORMAT command. With a 360K drive, you have the option of formatting the drive at 160K, 180K, or 320K. More about these option switches, and what they do, in a bit.

An important job of the FORMAT command is testing the diskette for media errors. When you initialize a diskette, the computer automatically verifies the format, looking for glitches in the tracks and sectors. If an error is found, the FORMAT command warns you of the trouble, and locks the irregular sector from future use. You have the option of using the diskette as is, with less than optimal formatted space, or tossing the diskette and going on to another.

We recommend you never use a diskette that contains errors reported during

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formatting. If DOS reports an error, try reformatting the disk; sometimes, the problem goes away. If the format error persists, throw the disk away, or save it (and collect it with other bad disks if necessary) and return it for a refund or exchange.

Using Format Option Switches

As with many of DOS's commands, FORMAT permits the use of several option switches you can use to control the initialization of your diskettes. Most of the switches influence the capacity of the formatted diskette. Others allow you to create a bootable diskette you can use to start your computer, provide a name for the disk, and more.

Here's a quick rundown of FORMAT switches, and how to use them. Note that you can identify a specific drive to format by including the drive letter after the FORMAT command, but before the option switches, such as:

FORMAT A: /S

Command

Drive letter

Option switch

• **/S** — The /S (for system) switch tells FORMAT you want to make a system diskette, one you can use to start your computer. System disks contain two invisible files and the COMMAND.COM command processor file. These files are copied to the diskette after formatting is complete. Example/What it Does: **FORMAT A:/S** Formats the diskette in drive A, and copies system files

• **/B** — The /B (for bootable) switch tells FORMAT you want to eventually make a system diskette, but does not copy the necessary system files to the diskette after formatting is complete. The /B switch is often used to create a diskette where the user adds the necessary system files later on using the SYS command.

Example/What it Does: **FORMAT /B** Formats the diskette and sets aside space for the system files.

• **/V** — The /V (for volume) switch informs FORMAT that you want to add a volume name to the diskette after initialization is done. Note: This switch is not necessary in DOS 4.0 or later; you are prompted for the volume name automatically. Example/What it Does: **FOR-**

[C:\] CHKDSK
Volume SYSTEM

created Jun 30, 1988 9:34a

29892608 bytes total disk space
53248 bytes in 3 hidden files
79872 bytes in 28 directories
21241856 bytes in 1056 user files
8515584 bytes available on disk

655360 bytes total memory
593616 bytes free

[C:\]

Screen representation of DOS version 2.x/3.x

MAT B: /V Formats the diskette in drive B; after initialization DOS prompts for a volume name. **FORMAT /V: DISK_NAME** Formats the diskette, names it "DISK_NAME"

- **/1** — The /1 switch formats the disk single-sided only, instead of the normal double-sided. As 99.99 percent of all PC users have double-sided drives there is very little reason you'd ever use this option switch. Example/What it Does

FORMAT A: /1 Formats the diskette in drive A to single sided; standard 360K 5 1/4-inch diskette becomes 180K

- **/8** — The /8 switch formats the diskette with eight sectors per track to make a 160K (single-sided) or 320K (double-sided) diskette on a 360K disk drive. As with the /1 switch, there is little cause to use this option. Example/What it Does: **FORMAT /8** Formats diskette to eight sectors per track; standard 360K 5 1/4-inch diskette becomes 320K

FORMAT B: /1 /8 Formats the diskette in drive B to single-sided, with eight sectors per track; standard 360K 5 1/4- inch diskette becomes 160K

- **/4** — The /4 switch is used with 1.2 megabyte 5 1/4-inch drives to make standard capacity 360K diskettes. Example/What it Does: **FORMAT /4** Formats high capacity diskette (5 1/4-inch, 1.2 megabyte) to 360K

- **/T** — The /T switch lets you specify the number of tracks you want on the diskette. This option is available in DOS versions 3.3 and 4.01 only. Example/What it Does: **FORMAT /T:40** Formats diskette with 40 tracks per side

- **/N** — The /N switch lets you specify

the number of sectors per track. This option is available in DOS versions 3.3 and 4.01 only. Example/What it Does:

FORMAT /N:8 Formats diskette with eight sectors per track

- **/F** — The /F switch, introduced in DOS 4.01, allows for "shorthand notation" to force a different capacity. Rather than use the clunky /8 or /4 switches, or specify the number of tracks and sectors using /T and /N, you can merely indicate the formatted capacity after the /F switch. Example/What it Does: **FORMAT /F:320** Formats standard 5 1/4-inch 360K diskette to 320K **FORMAT /F:720** Formats 3 1/2-inch 1.44 megabyte diskette to 720K

Using FORMAT with a Hard Disk

The FORMAT command works a little differently when using a hard disk. Hard disk drives require two types of formatting: low-level and high-level. Low-level formatting, which is typically accomplished using a special initialization program, arranges the tracks and sectors on the drive so that they can accept data.

Conversely, high-level formatting, done with the FORMAT command, establishes directory and file allocation space at particular spots on the drive. The FORMAT command doesn't really wipe clean the entire contents of the hard disk, as it does when used on a floppy disk. This is why utilities such as Norton and Mace can partially revive a hard drive that is accidentally reformatted.

Avoiding FORMAT Pitfalls

You can easily lose precious data

C:\>chkdsk

Volume EPHRAIM created 12-08-1989 5:34p
Volume Serial Number is 2E34-18E7

80162816 bytes total disk space
73728 bytes in 3 hidden files
77824 bytes in 30 directories
29640704 bytes in 1212 user files
50370560 bytes available on disk

2048 bytes in each allocation unit
39142 total allocation units on disk
24595 available allocation units on disk

655360 total bytes memory
549632 bytes free

C:\>
Screen representation of DOS version 4.0

through careless use of the FORMAT command. If you're experimenting, be sure to work with practice diskettes. Indicate the drive you want to format, such as FORMAT A:

and double-check the fail-safe prompt that DOS provides. If your computer is equipped with a hard drive, DOS will warn you one or more times that you are about to format the hard drive (DOS may refer to it as a "fixed" drive; it's the same thing). Answer No to the prompt and return to DOS, or better yet, just press Ctrl-C to safely cancel the command. The fail-safe warnings are most prominent in DOS 3.X and 4.01.

Finally, if others use your computer, and you are afraid they may accidentally use the FORMAT command, give it a new name. A name such as FORMAT!.COM, or DONTUSE.COM may be sufficient to ward off improper use. To rename the FORMAT command at DOS, move to the directory that contains the FORMAT.COM file, then type: RENAME FORMAT.COM NEW NAME.COM Use your own name in place of "NEWNAME.COM."

Understanding CHDKS

Utility software like Norton Utilities and PC Tools Deluxe are popular, in part at least, because they offer handy tools to find and diagnose problems with data disks. But did you know DOS has a perfectly good and quite powerful disk diagnostics program of its own? It's called CHDKS, for "Check Disk," is one of the more versatile DOS commands you have at your disposal.

You've probably used CHDKS once or twice to find out how much free space is on a disk, or how much memory is available in your computer. These applications are primary to the usefulness of CHDKS, but the utility of the command goes way beyond this. Let's take a closer look at CHDKS and discover its many hidden talents, and how to best use those talents to your advantage.

CHDKS at a Glance

CHDKS is available in all DOS versions since 2.0. With the exception of DOS version 4.0 and later, the CHDKS command has remained much the same. And, though DOS 4.0 introduces some changes to the CHDKS command, they are minor, cosmetic alterations that won't change the way you work.

CHDKS: five basic functions:

- Report on the amount of data space used and left available on your disk. This can be a hard disk or a floppy disk.
- Report the amount of system RAM (normally 640K) contained in computer, and how much is currently "free" (available for use by applications programs).
- List all the files contained on your disk, even within directories.
- Find and report files that are spread about the surface of your disks (file fragmentation).
- Repair certain disk errors.

To use CHDKS, type CHDKS at the DOS prompt. Example:

CHDKS

Then press Enter. If you are using ver-

sion 2 of DOS, you should first log onto the disk and directory that contains the CHDKS program file, CHDKS.COM.

When using later versions of DOS, you can invoke CHDKS from any drive or directory as long as the disk and path that contains the CHDKS program is indicated in the PATH= statement in your AUTOEXEC.BAT file. Normally, the CHDKS program is contained in the "DOS" directory, so the PATH= statement reads something like:

PATH=C:\;C:\DOS;

This statement line allows the operating system to find any executable program (or batch file) contained in the root or DOS directory, regardless of the currently logged directory.

Creating a Disk Report

When you start the CHDKS program, it analyzes the data on the currently logged drive, such as drive C: for your hard disk.

Let's review the information provided by the CHDKS program when used with DOS versions 2.x and 3.x:

Volume in...: Indicates the drive CHDKS has analyzed, such as A or B for a floppy disk in drive A: or B:.

nnnnnn bytes total disk space: Indicates the total amount of space, in bytes, available on the formatted disk.

nnnn bytes in x hidden files: Indicates the amount of space, in bytes, used by hidden files (DOS uses hidden files to create boot-up diskettes, and hidden files are also sometimes used with diskettes that use copy protection).

nnn bytes in x directories: Indicates the amount of space, in bytes, used to store directory entries.

nnnnnn bytes in xx user files: Indicates the amount of space, in bytes, used to store user (i.e. not hidden, system, or directory) files.

nnnnn bytes in xx bad sectors: Indicates the amount of space, in bytes, allocated to bad sectors.

nnnnnn bytes available on disk: Indicates the amount of space, in bytes, left available on the disk.

nnnnnn bytes total memory: Indicates amount of base RAM (conventional memory, not expanded or extended) installed in the computer.

nnnnnn bytes free: Indicates the amount of memory currently available (some RAM is always used by DOS, and additional RAM is often used by terminate-and-stay-resident programs, such as SideKick).



The basic CHDKS report for DOS 4.0 adds four additional lines:

Volume Serial Number: This is a randomly-selected serializing number added by DOS when the disk was originally formatted.

nnnn bytes in each allocation unit: Specifies the size of "allocation units," or clusters, used on the disk; generally 1024 bytes for floppies and 2048 or 4096 bytes for hard drives. Your computer records data on the disk one full allocation unit at a time.

nnnn total allocation units on disk: Specifies the total number of allocation units formatted on the disk, minus any reserved space used by system files.

nnnn available allocation units on disk: Specifies the number of allocation units left available on the disk.

Detecting File Fragmentation

When DOS stores a file on a disk, it places the data at the first available slot. If you subsequently erase one or more files, the storage slots that once contained the data is now free, and can be used again. When a new file is recorded, DOS will try to fit as much of the data as it can into the first available slots, and distribute any remaining data in later slots.

Over time, files recorded on a disk can be "chopped up" and may no longer be recorded in single units on the surface of the disk. When a file is scattered in many chunks it is said to be fragmented. File fragmentation makes your disk drives work harder, and it also invites big trouble in the event of even minor damage to the disk. The CHDKS program can be used to detect file fragmentation, so you know to re-order the files. To test for file fragmentation, type CHDKS and a file name, such as

CHDKS myfile.txt

CHDKS will first analyze the disk

and computer memory (as explained in the previous section), then check the indicated file for fragmentation. If the file is not fragmented, CHDKS reports:

All specified file(s) are contiguous. Or, if CHDKS detected the file was fragmented, the program reports:

Contains nnn non-contiguous blocks.

You can check many files at the same time by using the standard DOS wild-cards, * and ?.

***.EXE** checks all files with the EXE extension.

***.WK?** checks Lotus 1-2-3 worksheet files for any character in the last position, such as "BUDGET.WKS" or "YEARLY.WK1."

. checks all files.

Note that CHDKS only checks files in the current directory. If your disk is divided into subdirectories, you'll need to the CHDKS command for each one.

Detecting and Fixing Disk Errors

Sometimes, when you invoke the CHDKS command, it returns an ominous note:

nnn lost clusters found in xx chains. Write corrections to disk (Y/N)?

CHDKS has found some data clusters that are not part of any known file. In many cases, this is nothing to be alarmed about, as DOS (and many applications programs) sometimes don't "close" temporary files properly. However, in some instances it means that a file name has been somehow deleted, and its data no longer is connected to it.

While CHDKS gives you the option to "Write corrections to disk," no matter how you answer the program won't make any permanent effort to fix things for you. In order for the CHDKS program to actually correct a disk, you must invoke it using the /F (for "fix") option switch.

Before you use the /F option switch, you should first scan all the files in the entire disk and note any obvious omissions. This sounds far harder than it really is, because the CHDKS command offers a convenient option to list all the files, even those within directories. This is the the /V (for "verbose") option switch.

To list all the files on the disk, type

CHDKS /V

If you are listing files from a disk other than the currently logged one, type CHDKS, then the drive letter, then the /V switch. Example:

CHDKS d: /V

This displays all the files on drive D:.

More than likely, the files on the disk will skip by on the screen, making it impossible for you to review them. If this is the case, re-direct the screen output to a disk file, using the command

CHDKS /V > diskfile.txt

Of course, you can use any name in exchange for *diskfile.txt*. View the file using any word processor, or with the DOS TYPE command. You are now ready to tackle the lost clusters. At the DOS prompt, type

CHDKS /F

When you see the prompt:

Write corrections to disk (Y/N)?

- Answer Y if you noted that you are missing a file you should have.
- Answer N if you noted you are not missing any files.

Answering No will cause CHDKS to adjust the file allocation table on the disk, and indicate the lost clusters are portions of the disk that are now truly empty. Answering Yes will cause CHDKS to save the lost data clusters in special files, named **FILEnnnn.CHK**, where *nnnn* is a number from 0000 to 9999 (CHDKS never erases old .CHK files, and numbers them sequentially to avoid losing any data).

Once CHDKS has confined the lost data in the .CHK files, you can review them with a word processor or HEX edit program to determine their origin. Text-only files should be fairly recognizable, especially if you created them in the first place. You may be able to recover all the text intact in one or more CHDKS .CHK files.

Binary data, such as that belonging to executable programs, is nearly impossible to decipher. Your best bet is to replace the lost data with a backup, or re-install the program from the original distribution diskettes.

Serious Disk Problems

The CHDKS program finds more than lost data clusters. It also detects more serious ailments with the directory or file allocation table on your disk (the file allocation table, or FAT, defines the exact location of all data clusters on your disk, and notes which files belong to what clusters).

CHDKS may report two error messages; either one may indicate a serious problem with your disk. The message:

Allocation error, size adjusted

means the file size reported in a directory is larger than the number of clusters that are supposed to belong to that file. The

message:

Invalid cluster, file truncated

means the reverse — there are more clusters than the file size indicates.

If either of these messages appears, try to locate the offending file, and examine carefully. Make a copy of it, then run the CHKDSK program once more, this time with the /F option switch, so the problem is corrected.

Be prepared to forfeit data. CHKDSK may loose track of some valid data, or may over-write data belonging to a good file. For this situation, you may wish to use a third-party disk repair program, like PC Tools Deluxe version 6.0, or Norton Utilities.

CHKDSK may also indicate a “cross-linked” file, displaying the error message: **FILE.EXT is cross linked on cluster nnn**

Cross-linking occurs when the same data on the disk appears to be used by more than one file. The /F can be used to try to separate the data ownership. Note that some data loss can occur, so you'll want to verify the integrity of the files after CHKDSK is through.

Finally, two serious disk errors the CHKDSK program can't correct are the ominous:

Disk error reading drive xxx

Abort, Retry, Fail?

and

Sector not found error Abort, Retry, Fail?

These errors indicates that important data on the disk can't even be read. Before throwing the disk out, press “R” to retry, then attempt to recover the data using a disk repair utility.

Copy Power

The COPY command is the “Xerox machine” of the DOS world, allowing you to make individual copies of one or more files on your disk. You might use COPY, for example, to prepare a data disk for a co-worker, or create extra “accident prevention” copies of an important electronic spreadsheet file as you experiment with adding formulas and functions.

Undoubtedly, you've already used the COPY command, and you probably know how to make simple copies from one disk to another, or from one hard disk directory to another. But are you aware of the special options you can use with the command to verify the newly copied program, ways to “copy” files to printer ports, and using the command to combine two or more files to make one?

Let's take a closer look at the COPY command. You'll learn how to use it, how to properly apply its optional switches, and how to avoid copying mistakes.

Inside the COPY Command

The COPY command is available in all versions of DOS, and is internal to the operating system. That is, there is no stand-alone executable program for the DOS command. You need only to type the name of the command, the file you want to copy, and the desired destination, such as:

COPY myfile B:

This copies the file “myfile,” which resides in the current disk and directory, to the disk in drive B:. In this case, the name of the copied file is the same as the original. If you want to give the copy a new name, type

COPY myfile B:filename

This makes a copy of “myfile” in drive B:, and names it “filename.” In DOS terminology, “myfile” is the **source** and “filename” is the **target**.

If you are not in the directory that contains the source file, you can indicate the drive and path, as needed.

COPY C:\memos\myfile D:\letters\myfile

This copies the file “myfile,” which is in drive C within the memos directory, and places it in drive D, under the letters directory. You can, of course, provide a new name for the target file, such as **D:\letters\newname**.

DOS allows you to use wildcards when copying files. This lets you copy more than one file at a time. Here are some examples:

COPY *.* Copies all files

COPY *.EXE Copies just program files with an EXE file extension

COPY BUDGET? Copies all files that start with “BUDGET” and end with a single character, like “BUDGET1” or “BUDGET2.”

Ordinarily, you will copy files from one disk to another, or from one subdirectory to another. Using one of the example from above, the complete command line would be something like this:

COPY A:*.EXE C:\PROGS

or

COPY A:*.EXE C:\PROGS*.EXE

This copies only those files from drive A: with the file extension of EXE, and places the copies on drive C:, under the PROGS subdirectory. Notice that you don't strictly need to provide the file name and wildcard for the target (this

applies to single or multiple file copying), but it's a good idea to get into the habit.

If you want to make a copy of a file and keep the copy in the same directory as the original, you absolutely need to provide a new name. Failure to provide a different target name from the source will cause DOS to report an error:

File cannot be copied onto itself 0

File(s) copied If you are copying a single file, the easiest approach is to move to the directory that contains the file, and issue the command, such as:

COPY oldfile newfile

Of course, use your own file names for “oldfile” and “newfile.”

If you are copying multiple files using wildcards, use the same wildcards for the target, but change the base characters of the file name. For instance, if you are copying all batch files, using the wildcard name *.BAT, you must enter a command such as:

COPY *.BAT *.FIL

This copies all .BAT files and makes new files with .FIL file extensions.

Creating File from the Keyboard

An unusual application of the COPY command is to create a short text file directly from the DOS prompt using the keyboard for data input. You might use this method to create a simple AUTOEXEC.BAT batch file, or CONFIG.SYS configuration file for your computer.

To create a file from the keyboard, type:

COPY CON filename

In place of “filename” provide your own unique name for the file, such as CONFIG.SYS or STARTUP.BAT. Press Enter and DOS will seem to go to sleep. You won't see the familiar DOS prompt.

Now just start typing. End each line with a hard return. After the last line, press the Enter key one more time, then press the F6 function key. This adds a ^Z (control-Z) end-of-file code, which DOS needs when it plays back the file. Press Enter one last time. If everything worked properly, DOS will report that one file was copied.

You may be wondering how this command works. The COPY command can be used to copy actual files, or copy data from a piece of hardware on your computer. In this case, the CONsole is the keyboard. The source filename is CON (the keyboard), and the target is “filename.” You can also use this feature to redirect files to a printer port, as detailed

below.

While the COPY command is a relatively painless way of creating simple text-only documents, it's obviously not a method you'll want to use if you are building a large file, or want to edit the contents of an existing file. Use a word processor or text editor instead.

Redirecting File Output

The COPY CON techniques is used to capture your keystrokes and store them in a file. In a comparable manner, you can use COPY with DOS to send a disk file to a printer. The technique is easy. The following example shows how to print the file "filename" on a printer connected to the LPT1 parallel printer port:

COPY filename LPT1

You can substitute LPT1 for another active printer port installed in your computer, including any other parallel port (such as LPT2), or a serial port (COM1, COM2, etc.).

Before you issue a copy-to-printer command, be *absolutely* sure the printer is turned on, is on-line, and is connected properly. Otherwise, DOS may hang trying to print the file. If this happens, you can usually return to DOS prompt by pressing Ctrl-C, or Ctrl-Break.

File Verification

Computers make mistakes from time to time. Typically, these mistakes are caused by faulty media — a bad disk or perhaps a disk drive that's in need of cleaning or repair. Errors in file integrity can wreak havoc; a file you believed was intact is in fact filled with data errors.

Normally, DOS does not check the integrity of files it creates when using the COPY command, but you can force the issue if you wish. Simply add a /V after the COPY command and filenames. This instructs DOS to verify the copy. For instance, the command:

COPY oldfile newfile /V

copies "oldfile" and makes "newfile," then checks "newfile" and searches for errors. Note that the verification DOS uses is not foolproof, but it works 99.99 percent of the time. You can use the /V switch for single or multiple copies.

Combining Files

Sometime, you may wish to combine two or more files into one file. A typical application is chaining a series of text files to make one larger file. The COPY command can be used for this, too.

COPY file1 + file2 + file3 newfile

This copies the files "file1," "file2," and

"file3" and creates a new target file named "newfile." The command line is shown with spaces between the plus signs and the file names, but DOS does not require this. You may find it easier to type the command line without spaces.

Unless you tell it otherwise, DOS assumes the files you are combining are ASCII, and contain just printable text. However, if you want to combine binary files, you need to use the /B switch. Once you use the /B switch in a single COPY command, DOS assumes the remainder of the files are binary as well. If necessary, you can combine ASCII and binary files into one file by using a composite of /B (for binary) and /A (for ASCII) switches. The order in which you enter these switches can be important, so use this feature with care. Here is an example:

COPY file1/B + file2 + file3/A newfile

The files "file1" and "file2" are binary, and "file3" is ASCII. All three files are combined into a single file, named "newfile." The /B turns on the binary switch for the first and second files, and the /A resets the switch for the third file.

Dangers of the COPY Command

For all its features and capabilities, the COPY command suffers from a number of limitations. Perhaps the worst: the COPY command is ignorant of files that already exist on your disks. Should you copy a file with the same name as one that already exists, DOS will dutifully carry out your request, and will overwrite the original.

The COPY command is only aware of file names, not other important information about a file, like date of creation, or archive bit setting (the archive bit indicates if the file has been recently backed up). Therefore, you can't simply copy all the files created today, or since a particular day, or only those files that have not been recently archived.

Furthermore, the COPY command does not give you individual control over multiple file copies. Once you select a batch of files to copy (like COPY *.*), all the files you've identified are copied. Sometimes, you want to copy all files except one or two.

Abort, Retry, Fail?

If you've been using your PC for any length of time, you've seen these dreaded words: "Abort, Retry, Fail." These words, or close cousins to them (depending on the version of DOS you

are using) are an unsubtle hint that something is amiss in your computer. The messages tells you DOS is having trouble retrieving some important data, typically from a floppy disk or a hard disk.

In some instances — like when you forget to close the disk drive door — the message is just a reminder to fix a minor problem. But in other instances, the message could mean your hard disk has crashed, or that the data on a floppy disk has been scrambled.

Let's take a closer look at "Abort, Retry, Fail" and learn what it means and how to interpret it to locate the problem.

Variations on a Theme

Abort, Retry, Fail actually comes in a number of flavors. In DOS versions prior to 3.3, the message reads "Abort, Retry, Ignore."

- Abort means to terminate the current program that is running, if any, and return to the DOS prompt. If you are already in DOS, choosing Abort often doesn't do anything noticeable — if the original problem remains, so does the error message.

- Retry means to attempt the command (usually fetch data from a disk) again. In fact, DOS will try it four times, and if the results are still unsuccessful, the error message re-appears.

- Ignore means to pretend the problem doesn't exist, and ask DOS to go on. In some cases, this works, but in others — where it is crucial to write or read data on a disk — Ignore will have no effect. When you tell DOS to Ignore the error, DOS will not report the problem to any application programs you happen to be running. This can be potentially dangerous, and further data loss could result.

DOS 3.3 introduced a fourth alternative, Fail. Depending on the actual error, Fail will supplement Ignore, or will replace it. Fail works much like Ignore, except that DOS will report an error to an application program that is currently running. Note that some programs are not intelligent enough to listen to DOS error reports, and the problem could go by undetected anyway.

To choose an option, type its first letter: A for Abort, R for Retry, F for Fail, and I for Ignore.

Responding to Abort, Retry, Fail

When you encounter the Abort, Retry, Fail message, do not blindly tap at the keys hoping for a positive response. Analyze what's wrong, attempt to cor-

rect the situation, then select an appropriate option. At best, responding to the Abort, Retry, Fail message will correct the problem and you'll be on your merry computing way.

At worst, you could accidentally force DOS to record data in a spot where it doesn't belong. Specifically, if DOS reports a problem reading or writing a floppy diskette, you should not remove that diskette, replace it with another, and choose Retry. This could cause DOS to overwrite good data with bad. If you cannot fix the problem by Retrying the current diskette, always choose Ignore (or Fail, depending on what's available) before changing diskettes.

Sometimes, nothing you can do will make the message go away. In this case, it may be better to restart the computer. You will lose any data you've been working on, but at least you won't damage the data already on your disks.

Following are common errors that trigger the Abort, Retry, Fail message. Note that the message occurs primarily when the computer has some difficulty fetching or sending data to some hardware device, such as a hard drive, floppy drive, or printer. In all cases, Abort, Retry, Fail appears with a specific error message, directing you to the problem.

- Not ready ready drive x: — DOS can't read data from a floppy or hard drive. This is most often caused by: not closing the drive door, failure to put a diskette in the floppy drive, or selecting the wrong drive (drive A: when you meant drive B:). If you can fix the problem, do so, and press Retry. If the problem cannot be fixed, press Ignore or Fail until DOS reports that the "Current drive is no longer valid."

- General failure reading/writing drive x: — DOS can't read or write data on the indicated drive, usually because the diskette is not formatted, not formatted completely, or not formatted for the drive (high capacity diskette on a standard capacity drive). Replace with a good diskette and try again, or press Ignore/Fail until the drive is no longer valid.

- Non-DOS disk — DOS knows the disk contains data, but it isn't data it recognizes, usually because the all important file allocation table (the roadmap on the disk to all the information recorded on it) has been damaged. Remove the diskette, inspect it, and Retry. Or, choose Ignore/Fail until the drive is no longer valid. You can attempt to revive the disk using a disk doctor utility program.

- Read fault error reading drive x: —

DOS recognizes a disk is in the drive, but can't read data on it. The disk may be inserted wrong, or not properly seated inside the mechanism. Remove the diskette, inspect it, and re-insert it. Press Retry to attempt to re-read the disk.

- Write fault error writing drive x: — Same as above, but DOS can't seem to write to the diskette.
- Sector not found on drive x: — At least DOS can access the disk, but some or all of the data it needs can't be found.
- Data error reading/writing drive x: — DOS can't read or write data on the diskette. Either one or more sectors on the disk are bad (this happens often with floppy disks) or the drive is malfunctioning — for example, the magnetic heads are dirty and need to be cleaned. Remove the diskette and inspect it. Reinsert it and Retry. If that doesn't work, choose Ignore/Fail. If the error occurs with other diskettes, it could indicate the floppy drive itself needs servicing. If the problem does not occur when using other diskettes, the drive is working properly. You can attempt to repair the damaged diskette with diagnostic software.
- Seek error reading/writing drive x: — DOS can't access one or more tracks on the diskette. This can be caused by an improperly inserted diskette, or a damaged disk. Remove the diskette, inspect it, and reinsert it. Choose Retry. If that doesn't work, choose Ignore/Fail.
- Write protect error writing drive x: — Oops. You forgot to remove the write protect tab from the diskette before trying to record new data on it. Remove the write protect tab and Retry.
- Error writing device PRN — PRN stands for printer; DOS is telling you your printer is not ready. Turn it on, make sure it is ready to accept data, and that all connections are secure. Retry.
- No paper — Your printer is out of paper. Replace the paper and Retry.
- Share violation reading drive x: — If you are on a network, someone else is currently using the file you want. You will have to wait until the file is closed, and Retry. If you are not on a network, it could mean another program has opened the file, and DOS won't let your current program access it. This problem can occur when using multi-tasking software like Desqview. Return to the other program, close the file, and Retry.

Solving Persistent Problems

If the Abort, Retry, Fail message appears more often than you'd like, it could indicate a more serious malady with your



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computer, its disk drives, or your diskettes. While it is less common than with floppy disks, DOS occasionally reports error reading or writing to a hard drive.

The typical problem is failure to find a sector, or read/write data in a sector. This indicates that a portion of the hard drive has become damaged, and should be fixed as soon as possible.

There are a number of hard disk management and repair programs currently out, including Mace Utilities, Norton Utilities, and PC Tools Deluxe. Even if you aren't plagued by Abort, Retry, Fail message, you should regularly use one of these programs to find and repair damaged portions on your hard disk.

If the problem still doesn't go away, even after you have repaired the damaged sectors on your hard drive, it could point to a more serious ailment of your drive, a bad hard drive controller card, or other faulty hardware. You should have your computer checked out by a professional technician.

The same goes for stubborn errors reading or writing floppy drives. You can periodically clean the magnetic heads in a floppy drive. If this doesn't do the trick, have the drive and/or your computer serviced.

Finally, should you find that a particular diskette gives you more than its share of problems, transfer the data from the diskette to a new one. Even high-capacity diskettes are relatively inexpensive considering the value of the data you place upon them. Of course, you should always maintain at least two copies of all your data and programs. Store the copies in a safe place in case something happens to the originals.

Having Problems?

Take a few moments to read through the following before calling your dealer or returning the computer. Odds are, the problem is a minor one, caused by something inconspicuous or obvious. The checklists at the end are geared toward non-technical troubleshooting. If you care to go deeper, refer to the Sam's Photofacts series on IBM PC/XT/AT repair and The IBM PC Troubleshooting and Repair Guide (also by Sams).

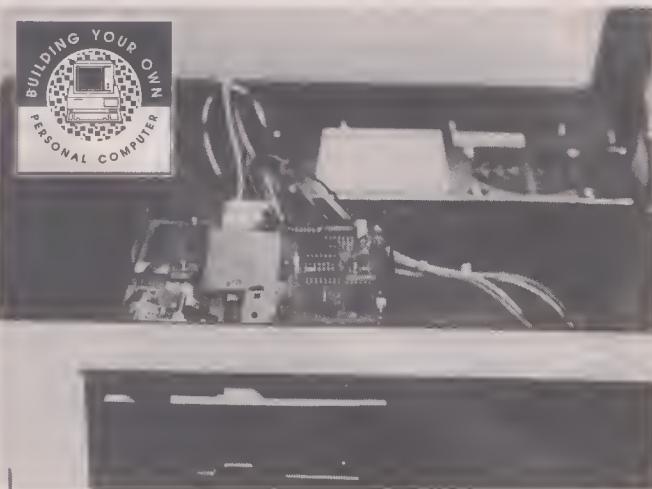
Before You Start

Before attempting to troubleshoot the problem, make sure of the following:

- Use DOS version 2.0 or higher (DOS 3.3 or above recommended).
- If the power supply has a multi-tap voltage switch, be sure it is in the 110 VAC setting (it almost always comes from the factory this way, but it's worth a check).
- If the wall outlet is the switched type, make sure that the power switch is on. Check with a table lamp to make certain that the outlet is active.
- Be sure everything is connected properly: the power supply cables to the motherboard and disk drives, the signal cables, the keyboard.
- When working with the computer, avoid leaving the case open when the computer is on. There is too much temptation to touch something when the case is open, or to remove or install a board or cable. NEVER remove or install a cable or board while the power is on.
- If you are having a lot of trouble with something, try the component in another computer. If the display adapter and monitor don't work, for example, try them in another clone.
- Some problems are caused by incompatibility between the software and the computer. To isolate the trouble, be sure to initially test the computer with MS-DOS only. Don't try to test the machine with an applications program, or with Microsoft Windows.

Problems with Power

Most of the power problems stem from improperly connected



cables. Check the cables to the motherboard and disk drives.

If the power supply turns on then shuts off (the fan will kick out), there might be too much drain on the power supply. Are there more than five or six expansion boards plugged in? You may need a larger power supply (150 watts).

Also, there might be a short to ground, typically caused by a circuit trace on the motherboard coming into contact with a mounting bolt or stand-off. In most cases, a

shorted motherboard will cause serious damage, so this situation is to be avoided at all costs.

Once you identify the problem as power related, turn the computer off immediately. You may ruin the power supply or motherboard if you continue to keep the computer on.

Problems with Disk Drives

Problems with the disk drives stem from three typical causes: Incorrect drive select switch/jumper setting, improper termination, wrong hookup to the signal cable.

Be sure to set the DIP switches/jumpers to reflect the assignment of the drive. Read the "Putting It Together" section for more details, or consult the manual that came with the drive. The termination resistor pack should be on the A: drive, not the B: drive. The signal cable that stretches between the drives and the controller card should be attached so that the very end is connected to the A: drive, the center connector is attached to the B: drive. This may not seem right, but it is.

Be certain that the signal cable is not reversed when you plug it into the controller card or disk drive. Doing so may erase the disk in the drive. Use a copy of the DOS disk, at least until you are certain that the drives are installed correctly.

Noisy drives are often the cause of something rubbing against the moving parts. If the drives are stacked on top of one another, try to put some space between the two. This prevents the bottom drive from interfering with the workings of the top drive. Also, be sure no cables touch the moving parts. Additionally, noise can be a problem if the drives are installed upside down. With almost all drives, the LED should

be on the top, above the slot where the disk is inserted.

Problems with the Display

Display problems are almost always caused by maladjusted controls on the monitor. Check all the controls — brightness, contrast, vertical hold, etc. Be sure that the monitor is properly plugged into the display card and that the card is firmly in place in one of the expansion slots.

When using an XT, the DIP switches on the motherboard must be set to reflect the type and mode of the monitor. The switches are set either to: none, monochrome (or both), color 40, or color 80. If you have both types of monitors installed, test the computer by taking one of the display adapters out and resetting the DIP switches. Try the computer with the one display board and monitor to see if the problem clears. Do the same for the other display adapter and monitor. Remember: you cannot have two color or monochrome display adapters installed at the same time.

Display problems can also occur when using a multi-display adapter, such as those that are switch-selectable between monochrome, CGA, EGA, and VGA. Be sure to set the DIP switch according to the type of monitor you are using.

Additionally, some AT and 80386 motherboards include a switch bank for setting certain system parameters, one of which may be display type (usually monochrome display set one way, all types of color display set the other). Be sure to read the instruction manual that came with the motherboard for further information.

Finally, be sure to check the cabling between the monitor and computer. It should be secure, with none of the connecting pins bent or broken.

Problems with Operation

Operational glitches are usually the fault of the disk used to boot the computer. Be sure that the disk is bootable and contains DOS. If possible, try the disk on another computer.

Problems in operation can also be caused by improperly installed RAM and ROM chips. Be certain the chips are oriented in the socket in the proper direction, and that there are no pins sticking out of the socket.

Be sure to also check the math co-processor, if one is present. A math co-processor that has been installed backward can cause your computer to operate erratically. Also, most all motherboards provide an option switch to indicate if a math co-processor is present. Set the switch accordingly. If you are using an AT or 80386 motherboard, you may also need to change the co-processor option in the setup routine.

Problems with Expansion Boards

If you are having trouble with an I/O board (serial and/or parallel ports), the most common problem is incorrect address settings. No two ports can share the same address, so if the board lets you change the address of the serial and parallel ports, flick the DIP switches or jumpers as instructed in the manual. Also be sure that the board is firmly seated in the expansion slot and that the cables connecting to the peripherals are on tight.

Some problems with connecting to the outside world may be the fault of the cable. The cable may not be properly wired for the printer or modem, for example. Check the design of the cable and make sure you are using the proper type. If possible, check the cable and peripheral with another computer.

In some cases, the problem will be related to the software, not the hardware. The software may not be communicating with the ports properly. You can test the operation of the serial and parallel ports when there is a printer connected to the computer. Try printing a screen dump (Shift-PrtSc) or direct the screen text to the printer by first typing Ctrl-P. Everything shown on the screen should appear on paper (turn printing off by typing Ctrl-P again). If you need to test a port other than LPT1, you must reassign the printing device. See the DOS manual on redirection and changing the PRN device.

Intermittent and Occasional Problems

You've had it happen to you before: the squeak in your car goes away the minute you drive into the service garage, but returns the next time you're alone with the automobile. The same thing can happen with the computer. Some problems seem to come and go, so tracking down their causes can be difficult. Here are some possible causes of intermittent problems:

- Bad power lines. Voltage spikes and sags in the power line may be affecting the computer. Invest in a power-line conditioner.
- Static discharge is disrupting the computer. A static discharge from your hand to the keyboard can lock up the computer, requiring you to restart it (of course, you lose the work you're currently doing). Avoid static by using anti-static mats on the table and floor (wear leather-soled shoes), and try to ground yourself to some other object before touching the computer. A static discharge on a disk can erase the contents of the disk.
- Bad RAM chip(s). One of the RAM chips may be bad. The chip may work, but its operation is marginal. If the chip serves in high RAM, it may not be always used. As the computer fills up its RAM, and moves data around, the faulty RAM chip may come into play. Temporarily replace some or all of the RAM chips. You can also test for bad chips by moving the RAM around the sockets. If there is a marked change in the effect, the RAM chips are the likely cause.
- If the motherboard is the turbo type, the high speeds may be interfering with the operation of some software, as well as certain computer operations, like disk reads and writes. Test this by manually shifting the motherboard into normal speed.
- The DOS or program disk may be bad. Sometimes, if only a small portion of the disk has been damaged or partially erased, the computer will still work, but it will behave erratically. Try another copy of the disk.

A Quick Overview of Troubleshooting

"Abort, Retry, Fail." You stare at the message on the screen, and don't believe your eyes. You know what it means — your computer can't read the data on its disk — but aren't sure if the problem is permanent, or just a temporary glitch. You try accessing the disk one more time, but the result is the same.

Time to throw in the towel, and bid your data good bye? Some computer errors are momentary; whatever the problem, it adjusts itself and you're on your merry way. Other problems are uncorrectable. A hardware or software error has affected your computer or the data on your disk drives, more than likely garbling whatever you were working on.

The problem is, which is which? How do you know when your computer is just playing dead and when it's really sick? If you're the panicky type, you may be tempted to rush your

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computer into the emergency ward at the first hint of trouble, but if the problem isn't a serious one — you could have diagnosed and corrected it easily — you'll spend a lot of money needlessly.

10 Common Computer Faults

1. Computer Doesn't Turn On. Perhaps the most disturbing problem is a computer that refuses to come to life. Occasionally, something inside the computer has gone awry — the power supply has gone on the fritz, or a fuse has blown. Most often, though, the problem is simple, yet one you may overlook. Check the power cord. Be sure it's plugged in at the wall and at the computer. If your computer is connected to a switched outlet (at the wall or at a centralized control panel), be sure the main power is on. Sometimes, the power cords themselves become damaged. Try a new one.

If none of these steps work, suspect the power supply inside the computer. Fortunately, power supplies are rather easily replaced, and do not cost too much. Before complete replacement, though, check the fuse inside the power supply (you'll have to remove the power supply from the computer, however). Replace the fuse with one of the exact same type and rating and try again. If the power supply blows out that fuse, then there's a more serious problem, either with the power supply, or with the motherboard, disk drive, or other hardware of your computer.

2. Computer Turns On, Won't Boot. Here, the computer is receiving power, but refuses to load its operating system and software. You can rule out a bad power supply or power cable; the machine is obviously getting juice. First, turn the computer off and wait a minute. Then, switch it back on. Try this a few times — often the computer will come back to life. Here's why this works: The heads in the hard disk may not have returned to their proper place when the machine was previously turned off. By cycling the computer a few times (and waiting a while before you turn it back on), you give the hard drive another chance to re-align its heads. If this doesn't work, try booting the computer from a floppy disk. The disk should contain the necessary system files for starting the computer. Your original DOS disks have the required files.

Should the computer start this time, run some diagnostic tests on your hard disk, to make sure it isn't seriously damaged. You may need to recopy system files to the hard disk, or — at worst — reformat the drive. You'll want to make a backup of the drive before reformatting.

Occasionally, a computer may appear to be receiving power, but the power supply is not delivering enough power, or not all the power (for example, the power supply provides +12 volts, but not +5 volts). Try a different power supply to see if the problem is fixed.

3. Computer Boots, But All or Most of the Data Appears Missing. The files on a hard disk that start the computer are grouped together, with your data files distributed throughout the disk. Two critical parts of your hard disk (and a floppy disk for that matter) are the file allocation table and root directory. Damage to either area can cause data loss. If your computer successfully starts, but denies you access to files you know are there, suspect misfortune in the file allocation table or root directory. Sometimes, these defects can be fixed with a utility program, such as PC Tools Deluxe, Mace Utilities, or Norton Utilities.

Utilities. Try your luck with these before reformatting your hard drive and starting over.

4. One or More Files are Damaged. Often, if files on a disk are damaged, the trouble is contained to just one or a handful of files. This generally points to a problem in the data portion of the disk, although the file allocation table and root directory can also be affected. Again, a disk utility program like Norton or Mace can help you reclaim your lost files. If the actual file was damaged, you may lose part of it. This usually isn't a problem with simple files like text documents, but it can pose real challenges with complex documents, like electronic spreadsheet files, or program files.

The best defense against data loss, particularly if your computer is equipped with a hard drive, is regular backups. At the least, you should back up your hard drive once a week, preferably every day that you use the machine. If you work with floppy drives, keep spares of program and document files.

5. Can't Write New Files. Your computer is working flawlessly, except that you can't create new files. When you try, the computer displays an error message. Often, the problem is caused by an incorrect BUFFERS or FILES command in your CONFIG.SYS file.

The CONFIG.SYS file, if you're not familiar with it, customizes the disk operating system to your computer and your special requirements. Two of the commands, BUFFERS and FILES, set aside memory and file space for both DOS and your application programs. Some software packages, like WordStar and WordPerfect, require that the FILES command (and to a lesser extent, the BUFFERS command), be set to at least some minimum number; any less and new files cannot be created.

So what are the correct settings for FILES and BUFFERS? It varies depending on the software you are using. Check the manuals for more details. You can view the contents of the CONFIG.SYS file with any word processing program, or by displaying it at the DOS prompt by entering: TYPE CONFIG.SYS

6. Accessing Disk Displays "Abort, Retry, Fail" Message. This message, and slight variations of it, indicate that your computer cannot access a disk or its data. If this happens with your hard drive, it could mean a serious problem. But before you haul your computer in for repair, try restarting your computer. If the problem persists, or is intermittent, make a backup of the data if you can, and reformat the drive. Or, use a hard drive diagnostic utility such as Advanced Disk Technician or SpinRite. These programs can be used to reformat a hard drive without losing data.

7. Disk Drive Makes Strange Noises. A disk drive that makes strange noise, like grinding or chafing, should be inspected immediately. A mechanical problem could exist, but often, the culprit is a disk label or write-protect tab that has fallen off a disk and is now entangled in the drive mechanism. Your hard drive shouldn't make any unusual sounds. If your hard drive chatters or squeaks, get it serviced right away.

8. Computer Suddenly Turns Off. A computer that turns off without warning may be suffering from heat overload, see "Looking Out for Heat," below). Wait for the machine to cool





Troubleshooter's Chart 1

Computer won't turn on.

1. Check power cord.
2. Check outlet (switch on); use table lamp to test.
3. Fuse in power supply blown; replace.
4. Power supply not connected properly; check.
5. Bad power supply; check and replace.

Fan turns on but nothing happens.

1. Make sure power supply is firmly connected to motherboord and disk drives.
2. Check ROM BIOS, reseat in sockets.
3. Check power supply; replace if bad.

Fan starts and stops in spurts.

1. Short; check insulating washers securing motherboord.
2. Overloaded power supply; remove some extra boards and/or get a larger capacity power supply.
3. Fault or short in connections to motherboord and drives; check.

Computer turns on but fails diagnostic test.

1. Inspect RAM for proper installation.
2. Inspect disk drive and display board for proper installation.
3. Check DIP switch headlings for correct RAM and video display settings (XT); check setup for correct RAM video display settings (AT).
4. Check for loose ICs on motherboard and expansion board.

Computer on, passes self-test, but the drive don't work.

1. Check controller card; press into slot.
2. Check power cable to each drive (Is cable reversed or not seated completely?)
3. Check signal cable from controller to drives. Reseat.
4. Check DIP switch or jumper settings on drive (both drives if necessary).
5. Check for termination resistor on drive A; and none on drive B.
6. Check DIP switch settings (switches 7 and 8) on motherboord (XT); check setup for proper disk drive selection (AT).

Computer won't acknowledge drive B:

1. Check cable to drive B.
2. Check for termination resistor pack on drive B (remove if found).
3. Check power cable for drive B.
4. Check DIP switch or jumper settings on B: drive.

down, and try turning it back on. If heat isn't the problem, inspect the power cord. Be sure it's plugged in all the way and shows no sign of damage. If the cord checks out, suspect a bad power supply.

9. Some or All Keys Don't Work. Your keyboard receives the most abuse of any component in your computer. Keyboards are not only subjected to the pounding of typing, but receive a good deal of fallout from airborne dust, hair, and other debris. Should one or more keys not function, try cleaning the keyboard. Check the cable from the keyboard to make sure it's plugged in all the way.

10. Computer "Freezes." A computer that "freezes" — stops dead and no longer accepts entry from the keyboard, may be an indication of a hardware or software fault. More than likely, the culprit is faulty (or "buggy") software. If the problem is easily reproducible, you should contact the publisher of the software and tell them of the error.

Looking Out for Heat

Heat is the natural enemy of computers. It warps hard drives and it bakes integrated circuits. Operating your computer even in moderately warm weather is a gamble you probably won't win, unless you take special precautions.

Dig That Cool Breeze

With few exceptions, desktop computers come equipped with cooling fans. These fans are designed to expel the heat that is generated inside the computer when it is operating.

The majority of this heat is created by the integrated circuits in the machine. Often, the faster the computer (like a super-up 386/33), the hotter the insides. Other parts of the computer generate heat as well, but to a lesser extent. These include the hard and floppy disk drives.

The cooling fan is typically housed in the computer's power supply. This fan is situated so that it sucks air through the computer, and flushes it out the back. In a well-designed computer, the air will circulate everywhere inside the machine, so that all the parts can be cooled. Unfortunately, not all computers are well designed when it comes to cooling, so certain components are never chilled the way they should be.

Of most importance is to keep the air intakes to the computer free. Block a cooling vent and the computer will eventually break down from over-heating, causing problems in operating. The typical PC clone has cooling slots in the front, often along the bottom lip of the case. You should keep these slots clear of paper and debris. Regularly brush or vacuum the area to get rid of accumulated dust.

For a thorough job, make sure the computer is turned off and that the hard disk is safely parked (run your hard disk parking program). Lift the computer from our desk and turn it on its side so you vacuum the undercarriage. Wipe the desk clean and replace the computer.

While you're at it, open the cover of the computer and vacuum out the insides. You'd be surprised how much dust can accumulate even after just two or three months of everyday use. Look for the fan intake and exhaust on the power supply module inside the computer (typically located at the right rear section of the machine). Clean as needed.

Making sure your computer can breath goes a long way in preventing your computer from succumbing to the heat, and

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that can avoid potential problems. Make it a point to clean it every couple of months. You can prevent early build-up of dust by placing covers over the computer and keyboard when the machine is not in use. However, you should not treat the covers as a substitute for regular preventative maintenance.

Many high-performance computers have extra booster fans built into them. The fans are most often positioned in the front left corner of the computer, and are designed to help keep cool the main circuit board, as well as any other expansion boards you have installed. As with the fan tucked into the power supply of the computer, you should make sure this fan is free from suffocating dust. If your clone comes with a booster fan, be sure to hook it up.

The fan usually connects to the power supply of the computer by way of one of the drive taps. Be sure to connect the fan to the + 12 VDC and GROUND connectors (pins 1 and 2).

Avoiding Boil-Overs

Even with the cooling system of your computer working in top-notch condition, high room heat can still bring your computer to its knees. If the temperature is uncomfortable for you, the same goes for your computer. Remember that inside the computer the temperature may be 20 to 30 degrees higher than the air in the room. So if you're sweltering in 95 degree heat, inside the computer it's 115 to 125 degrees.

Integrated circuits manufactured for consumer use (as opposed to military applications) are not designed to withstand temperatures much beyond 150 degrees. This is the absolute maximum temperature; the ideal operating temperature is more like 110 degrees or less. The defect rate increases as the heat increases.

You run a far greater risk of damage to your computer when running it in hot weather. Integrated circuits can literally blow their tops, and that means an expensive repair job.

The heat doesn't always destroy integrated circuits; sometimes, it just causes the circuit to shut down. When that happens, your computer goes on the fritz, and any data you were working on is forever lost. The circuit will operate again when it cools off.

If you have an air conditioner, use it. You don't need to keep the room frigid; set the thermostat to 85 degrees (preferably less) and your computer should be able to pull through the heat with you. If you don't have the luxury of an air conditioner, you should avoid using the computer during times of oppressive heat (room temperatures of 95 degrees or more). An extra room fan, pointed at you and the computer, should suffice in cooler temperatures.

Remember that your computer is chugging along even if you're not at the keyboard. If you aren't going to be using the machine for an hour or more, turn it off. That'll help cool it off, and will reduce the chance of a meltdown.

Beat the Hard Disk Heat

While heat is vexatious to integrated circuits, it's downright homicidal towards hard disks. Hard disk drives use a series of relatively thin magnetized metal platters to hold your sensitive computer data.

The platters are absolutely flat — at least they were manufactured that way. Heat can make the platters expand, and worse, warp! As the platters expand, the data impressed upon them moves, and the magnetic heads within the drive may not be able to find that Excel spreadsheet you've been working on.



Troubleshooter's Chart 2

Computer on, drives work, machine does not boot.

1. Make sure you are using a bootable DOS disk.
2. Close drive door to engage disk.
3. Disk may be inserted incorrectly; try again.
4. Bad disk; try another.
5. Check disk controller card.

No display (monitor is on).

1. Check controls on monitor-brightness and contrast.
2. Check cable from computer to monitor.
3. Check display board; press firmly into slot.
4. Check DIP switches on motherboard (switches 5 and 6); should reflect type of display installed (XT); check setup for proper display type (AT).
5. Check DIP switches/jumper blocks on display card.
6. Wrong type of monitor for the display card.

Display shows only gibberish or wrong colors.

1. Reboot computer; problem may disappear.
2. Check controls on monitor (horizontal and vertical hold, if available).
3. Check display board; press firmly into slot.
4. Check DIP switches on motherboard (switches 5 and 6); should reflect type of display installed (XT); check setup for proper display type (AT).
5. Check DIP switches/jumper blocks on display card.
6. Wrong type of monitor for the display card.
7. Check ICs on display adapter card; look for loose components and press back into sockets.
8. Check cable between monitor and computer; make sure it is firmly attached at that none of the pins are broken or bent.

Computer doesn't acknowledge full amount RAM.

1. Check DIP switches 3 & 4 on motherboard; make sure they agree with amount of RAM installed (XT); check setup for proper amount RAM installed (AT).
2. Check orientation of RAM chips in sockets.
3. Check installation of chip types in proper sockets (i.e. no 256K chips in sockets for 64K).
4. Check memory select jumper, if available. Jumper is used to indicate type of memory chips installed.

Computer locks up after a short period.

1. Check orientation of RAM in sockets.
2. Check for bent RAM pins not inserted into sockets.
3. Check speed of RAM chips — should be fast enough for computer speed.
4. Check orientation and installation of ROM chip.
5. If turbo motherboard, may be in turbo speed and interacting with software; switch to normal speed.
6. Power supply overburdened (remove some boards) or overheated (allow to cool).



Troubleshooter's Chart 3

Printer or modem does not work.

1. Check I/O board; press firmly into socket.
2. Check cable from computer to printer/modem.
3. Check switch settings on I/O board; do they reflect proper port addresses? Check manual that came with board for details on how and when to set the port address switches/jumpers.
4. On AT style clones, check setup for proper parallel and serial port designations.
5. Look for interacting boards. Does the computer already have an LPT or COM port with the desired port address?

Computer won't log onto hard disk drive.

1. Drive not initialized and/or formatted; check and reformat, as needed.
2. Check drive controller card; press firmly into place.
3. Check signal and control cables between drive and controller.
4. Check power cable to drive.
5. Check switch/jumper settings on controller; must match size and type of drive you are using (consult manual that came with the drive for details on how to set the switches/jumpers).
6. On AT style clones, check setup for proper drive type designation.

Pressing some keys has no effect.

1. Keyboard switches dirty; depress several times to clear up debris, or clean keyboard.
2. Keyboard faulty, repair or replace.

Nothing happens when any keys are pressed.

1. Check keyboard cable leading to motherboard.
2. If keyboard light glows, reboot computer and try again (use floppy drive you have a hard drive).
3. Check AT/XT switch settings on underside of keyboard (if present). Select proper computer, as needed.

Newly installed expansion board does not work

(but computer passes self-test).

1. Check board in slot; press down firmly to set board into slot.
2. Check DIP switches/jumpers on board; check with manual.
3. Two I/O ports given the same address (LPT or COM); check and reassign the ports.
4. Two monochrome or color boards installed; remove one.
5. Check cables from board.
6. Pins in slot not making good contact with board; reinster again or try a different slot.

If this happens, turn the computer off and wait for it to cool (generally an hour or more). The platters should contract and your data can be retrieved.

In extreme heat, the platter can be deformed, and permanently warped. Generally, there is no fix for this problem, other than replacing the hard disk drive. Of course, any data on your drive is irretrievably lost. Once again, good reason for regular back-ups.

Dealing with Dead Disks

The sinking feeling is unmistakable: you attempt to retrieve a file you've been laboring over, and your computer refuses to display the data. No matter what you do, you cannot access the disk or its information, and you soon realize that your work is locked out of your reach. Your data is stranded in an ocean of magnetic particles on the disk, with no safe harbor in sight.

Other than your entire computer going up in flames, the complete loss of the data on a disk is the perhaps the worst thing that can happen to you. Forget all about CPUs, memory, watts, and interfaces; it's the data that matters. If you can't access the data you've put in the computer, it's useless to you. After all, what goes in ought to come out.

The sad truth is that damaged disks are not rare. Odds are, one time or another, you will experience a dead disk, and you'll be unable to access the data on it. Knowing it can (and probably will) happen will help you better formulate ways to contain the loss. You can limit your injury by careful application of a combination of preventative and corrective measures.

Garbage In, Garbage Out

Deals are aplenty in the computer biz these days. You can buy a complete computer for less than a thousand dollars, and that includes hard disk and monitor.

But how good is it? Do you feel safe entrusting your data to a bargain-basesement no-brand machine? Chances are, the computer is fine and every bit as good as brands costing several times as much. But inferior parts can lead to an early demise of data. This is particularly true of the hard disk drive. A cheap drive isn't made for longevity. Before year's end data will spill out and you won't have a sponge to clean it up.

If there's a critical component in a computer, it's the hard drive, so at the very least get one that you can trust. Price is a poor yardstick, but you can suspect the drive is below par if it costs less than \$150 (assuming a capacity of 20 megabytes or more). Good models start at about \$200, with many of them in the \$300 to \$500 range. This includes the controller card used to electrically connect the hard drive to your computer.

The older the computer and hard disk, the more likely it will lose data. Although the modern hard disk drive has a life expectancy of five to ten years, you may want to have it overhauled every two or three years. A number of computer service centers will realign and reformat your hard drive, then test it for critical problems. Over-the-counter programs like SpinRite or Disk Technician can also be used to rejuvenate a hard drive and help return some of its lost luster.

Regular Backups

By far, your best hedge against data loss is archival copies of the information on your hard drive. If you don't use a hard drive, then you should make regular copies of your floppy diskettes. Label them "original" and "backup," and keep them

TROUBLESHOOTING

in separate places.

The MS-DOS operating system comes with a hard disk backup program, but you'll find most any of the third-party archival programs much better. There are a number to choose from, like Fastback Plus, PC Tools Deluxe, Norton Backup, and DMS/IB (formerly Intelligent Backup). All these programs allow you to selectively back up certain files or certain directories, and provide automatic and manual control of the archival process.

Backups are most easily made with a streaming tape drive. These accept tape cartridges; of the two tape drive formats in use, the smaller format uses cartridges that look a lot like audio cassettes.

Both types will archive the data on your hard disk at the rate of about two or three megabytes per minute — often faster. You can also use floppy disks to hold the backup data. But you need to be there to swap the disks in and out of the drive.

To be useful, you should archive all the data on your hard drive once a week. Assuming you use your computer daily, you should perform an "incremental" backup at the end of each working day. An incremental backup only records those files you created or edited for that day.

If you back up your hard drive less frequently, you run the risk of harboring stale data. Should your hard drive go out days or weeks after your last backup, the data you retrieve from the archive will likely be too old to do you much good.

Disk Reconstruction

Even with the best backup plans and hard drives, you may lose data and not have a reliable means to replace it with an archival copy. In some cases, you can resurrect your hard drive using a disk-fixing program. The top three are PC Tools Deluxe, Mace Utilities, and Norton Utilities Advanced. All three help you stitch a wounded disk back to health.

The process is not always 100 percent successful, nor is it fool-proof. So you should attempt to use disk-fixing programs

only as a last resort, and only if you know at least a little about computers and hard disk drives. Of the three products out, PC Tools Deluxe (version 6.0) offers the most automatic disk repair facilities, and is most useful to the computer neophyte.

To play it safe, you may want to use the data safe-guarding utilities that accompany these programs. For example, PC Tools Deluxe comes with a special program that takes "snapshots" of the critical data portions of your hard disk. In the case of damage to these portions, you can use these snapshots to piece the information back together again.

If you suspect a problem with your hard disk — data that should be there cannot be recovered, for example — you should run the DOS CHDKS program, or a disk diagnostics utility before doing anything more drastic. You can easily make matters worse by rushing to the aid of a hard drive that isn't really sick.

By all means, you should not delete files or subdirectories (even if you no longer need them) or use a data "defragmenting" program, until you are sure all the data on your drive is intact. These could turn a minor bump into a brain tumor.

Who You Gunna Call?

If your data problems have you over a barrel, as a last resort you can call in an expert. Talk to your computer dealer or a local computer repair depot for suggestions. You may need to take the entire computer into the shop, so you'll be without it for a while. That can be tough if you need it for your day-to-day activities.

Another approach is the independent consultant, most of whom will visit you at your office and work on your computer there. Consultants and repair techs get about the same amount of money per hour, about \$45 to \$75, so there's not a large difference in cost. Be sure to find a consultant who specializes in retrieving lost data. Many come equipped with satchels of specialized utilities and diagnostics programs, and may or may not take your computer apart to locate the problem.

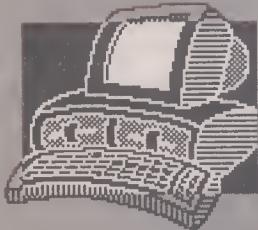
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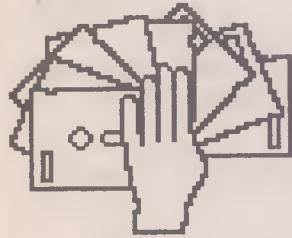
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WHAT YOU NEED TO KNOW ABOUT DISKS

Removing the mystery makes them easier to use



You know that disks are used to hold the programs and data you use on your computer. But you may not know how the data is structured on the disk, and how directories or files are recorded so that your computer can find the programs or documents it needs.

Understanding how data is organized on hard and floppy disks helps you develop methods for storing files more efficiently. You'll also learn how some errors on the disk can cause easily correctable data glitches, while other errors can render the entire disk useless.

Anatomy of a Disk

Data on a IBM PC or compatible computer disk (floppy or hard) is recorded in concentric tracks. If you could see the tracks, they would appear as rings starting at the center of the disk and spreading outward. Unlike the groove on a record, which is a continuous spiral from the outside to the inside, computer disk tracks are self-contained rings.

The number of tracks varies between media type and capacity. Standard double-sided, double-density (360K) diskettes contain a total of 80 tracks — 40 on each side of the disk. A moderate size hard disk, say about 40 megabytes, may contain 600 or more tracks, divided among three or four physical disks.

The data on the disk is further divided into sectors. A sector is a particular segment of the track. By dividing each track into individual sectors, the computer can more readily store and later retrieve data. As with tracks, the number of sectors differs from disk to disk. Regular IBM 360K floppy disks

contain nine sectors per track; many hard disk drives use 25 or 30 sectors per track. Some hard disk drives exceed 31 sectors per track, but these are considered "non-standard" to many PC programs, especially hard disk utilities. Be wary of using more than 31 sectors per track - some of your programs may not function properly.

Just as tracks are composed of many sectors, sectors are sub-divided into clusters. A cluster is the smallest unit the computer can manipulate. Cluster size is expressed in K bytes (1,024 bytes), and determines the smallest amount of space that a given file will take up. Even if a file is only 2 bytes long, it will still consume an entire cluster. Your computer will fill the extra space with blank characters.

The cluster size in double-sided, double-density media is 1K. That means that file size is always in 1K increments. If a file is 500 bytes, for instance, it still takes up 1K of actual disk space (although its size is still listed as 500 bytes). By extension, if a file is 1,025 bytes, it will consume two clusters, or 2K of space.

Generally speaking, cluster size increases with larger media. Hard disk drives generally have cluster sizes of 2K to 4K. With a 4K cluster size (as found on 10 and 20 megabyte hard disks for the IBM PC/XT), minimum file size is 4096 bytes.

Each disk you format on your computer — whether it's a hard or floppy disk — is composed of four parts: the boot record (or boot block), the file allocation table, the root directory, and the data area. These parts are located on the disk in a specific sequence starting with the boot record and ending with the data area.

Depending on the type of media and its capacity, the physical size of the file allocation table, root directory, and data area may vary from disk to disk.

Boot Record

Every disk has a boot record, even if the disk isn't "bootable"; that is, even if you can't use it to start your computer. The boot record contains vital information that your computer uses to begin operation when it's first turned on. If the disk also contains the necessary system files (IBMBIO.COM, IBMDOS.COM, and COMMAND.COM), the computer will start up and you can begin work. If the disk lacks system files, and you try to use it to boot your computer, you'll get a "Non system disk" error.

The data in the boot record is necessary if you want to use the disk to start your computer with that disk. If something

happens to the boot record data, it's likely that the disk will no longer start your computer.

File Allocation Table

The file allocation table, or FAT, can be likened to an attendance sheet in a school room. On the sheet is a check box for each student in the room. When a student is present, the corresponding checkbox is marked. When the student is absent, the checkbox is empty.

The FAT records all the clusters on the disk that contain valid data. Valid data is considered a file that you (or your computer) record on the disk, but have not yet erased. Once you erase a file, the space on the disk that contained the deleted file is now considered free, and can be used to store a new file.

It's important to note that the file allocation table is not really a directory of files on the disk, but rather a scorecard of clusters that are either occupied (also called allocated) or empty, along with which clusters belong to which files.

The size of the file allocation table depends on the capacity of the media. On 360K double-sided, double-density PC disks, the FAT for the root directory can hold up to 112 files. DOS will report an error if you try to record a 113th file on the disk. You can, however, store more than 112 files on a 360K diskette, but the files must be stored in a sub-directory, not in the root directory.

Damage to the FAT can be disastrous; your computer won't be able to tell a full disk from an empty one, and it won't know what portion of the disk holds a particular file. Files are often stored in many clusters, and the clusters aren't always together on the disk. An error in the file allocation table can corrupt data retrieval because the computer may fetch only a portion of the file, and not all of it. Or worse, the computer may retrieve part of one file, and part of another, thinking both parts belong to just one file.

Root Directory

Every disk has a root directory, even if you don't use subdirectories. The root directory contains a list of all the files and subdirectories contained within the disk (from the root directory, subdirectories are treated like files). Damage to the root directory generally means that one or more of the files or subdirectories on your disk are inaccessible.

The root directory plays an important role when formatting a hard disk using the DOS FORMAT command. Because reformatting the entire disk can consume a lot of time, DOS takes a shortcut and simply erases the file and subdirectory names in the root directory. The actual files and subdirectories remain. This is why many hard disk utility programs like Mace Gold and Norton Utilities include features for restoring the data on a hard disk even if you've reformatted it.

Data Area

The actual files — whether they are contained in subdirectories or not — are placed in the data area of the disk. Each file consumes a specific amount of the data area, as dictated by the size of the file and the cluster size of the disk.

Files larger than the cluster size are distributed among two or more clusters. These clusters may not always be together (contiguous) on the disk. In fact, depending on how often you erase and add data, files may be strewn all over the disk. By using a file de-fragmenting program, such as PC Tools Com-

press (part of the PC Tools Deluxe package), or OpTune, you can rejoin all the files, thus making your computer and hard disk more efficient.

A Real-World Application

You can apply what you've learned about sectors, clusters, file allocation tables, and so forth to reclaiming programs and documents you accidentally erase from your disks.

Many PC users are surprised to learn that erasing a file from a hard or floppy disk doesn't actually obliterate the data. Rather, it deletes the file entry in the disk directory, and updates the FAT so that DOS understands the space previously occupied by the file is now available for use again. This information is stored in the directory and file allocation table of the disk. When DOS deletes a file entry, it marks it as "erased" and removes the first letter of the file name. For example, if the file name was REPORT.DOC, when erased the file becomes EPORT.DOC.

A number of popular utility programs, including Norton Utilities Advanced, PC Tools Deluxe, and Mace Gold, include an "undelete" or "unerase" feature for retrieving files you have accidentally erased.

During the undelete process, the utility program selects those files that have been recently deleted. You select the file you want to recover, add the missing letter at the beginning of the file name, and utility program takes care of the rest.

For best results, you should recover accidentally lost files IMMEDIATELY after erasing them. That way, there's no chance that DOS will refill the space on the disk with new data. If you delete a file, then go on and store several others, there's a good chance that DOS will fill at least some of the empty space provided by the erased file with other data. You CANNOT retrieve a lost file if other data has been written over it.

SHAREWARE

The try it before you buy software



You've read nothing but praise for the XYZ word processor, and you're dying to try it out yourself. They want \$195 for the XYZ program — not a lot compared to some other word processing software, like Microsoft

Word or WordPerfect, but enough that you double-check your bank account to make sure you have the cash to cover it.

You buy the program, install it on your computer, and put it through its paces. With each passing minute you grow more uncomfortable: you find this odds-on favorite of little value to you. Sure, it's got a couple of nice features, and the program is fast, but it doesn't do even the rudimentary tasks you need. Disgusted, you take the program back to the dealer and ask for a refund. The sales person chuckles and merely points to a sign pasted onto the counter: It reads, "Software Not Returnable if Package Has Been Opened."

The only way for you to be sure a program is truly "right" for you is to try it out personally. You can test-drive some programs at the dealer, but this is impractical for major pur-

chases of more sophisticated programs, like databases, word processors, and spreadsheets. Many computer dealers refuse to accept software for return if the package has been opened. Their reasoning is somewhat understandable: Most computer software can be readily copied, and an unsavory customer might buy the program, make duplicates of the diskettes, and return it for a full refund. A few software stores (like Software Etc.) offer money-back guarantees, but most don't. That doesn't mean you're left out in the cold. With something called "shareware," you can try out software before you buy. The trial period can be days, even weeks — whatever it takes for you to feel comfortable with the software.

Shareware also caters to the unusual. To be successful, a commercial program purchased at a retail store must be aimed at a large segment of the computer market. This limits the variety to the old standards, like word processors, database managers, and electronic checkbook registers. With shareware, you'll find complete editions of the Bible, unique educational programs for teaching everything from accounting to zoology, and fun games like trivia, arcades, and miniature golf.

If you like the program and continue to use it, you're expected to pay a registration fee. This fee ranges from \$5 for simple utilities to over \$100 for sophisticated productivity software.

Shareware is available through a unique distribution channel called the shareware clearinghouse. Most clearinghouses are mail order companies who charge for the distribution of the program diskette, but not for the actual software. Prices range from around \$1 to \$4 per diskette; most programs are contained on a single floppy. Sometimes, more than one shareware program is included on the disk.

Shareware clearinghouses advertise in all the major computing magazines (names and addresses of selected shareware companies appears in Table 8-1). The larger companies publish a full-page ad that lists their best sellers, like Bowling League Secretary, Typing Tutor, or PC-Books (accounting software). If you don't see what you want, ask for a catalog. The catalog lists many other programs that may be of interest to you.

Most clearinghouses cater primarily to the IBM PC, but a few also support the Apple Macintosh, Commodore 64 and Amiga, and Atari computers.

Once you get your disks, you can try out the software and see if you like it. Read the on-disk manual (print it out for future reference if you like) to learn the restrictions you are under when using the software. Most shareware authors allow you to use the program for a "reasonable" amount of time before they expect you to pay for it. The definition of reasonable is debatable, but you should feel comfortable with testing the software for two or three weeks.

If the program proves beneficial to you, send a check to the software author. The name and address are usually located in the documentation file. Send only a check, never cash. Refrain from sending a money order or cashier's check. The reason: Like all of us, software authors move and may not be at the address listed in the on-disk manual. Should your payment not reach the author for one reason or another, you won't be out the money if you pay by personal check. On the other hand, the bank gets to keep your loot for an uncashed money order or cashier's check.

While many shareware programs are every bit as good as

Mail Order Shareware Companies

5 'N 10 Software 2414 S. Fairview Ste. 105A Santa Ana, CA 92704	JF Company's Software 10058 Dove Oak Ct. Cupertino, CA 95014
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Gemini Shareware 555 Clarke Rd. Coquitlam, B.C. V3J 3X4	Software Excitement PO Box 3072 Central Point, OR 97502

the commercial stuff, you'll often run into dogs that aren't worth the diskette they're on. Fortunately, it doesn't take long to spot the losers.

The term shareware is often used to denote a wide variety of alternative distribution software. Not all of the programs you may buy from a "shareware clearinghouse" require a registration fee. Some are absolutely free with no obligations and some are demonstrations for commercial products. Let's categorize the software you are likely to find at a shareware clearinghouse:

- Shareware. The software author has copyrighted the program and expects to be paid a registration fee if you keep and use the program.
- Public domain. A true public domain program is uncopied, and you can use it, modify it, and resell it as you like (you just can't copyright it in your name). However, most so-called "public domain" software really refers to copyrighted programs that don't require a registration fee.
- Freeware. The original term for shareware, now generally regarded to mean copyrighted programs that are distributed free of charge.

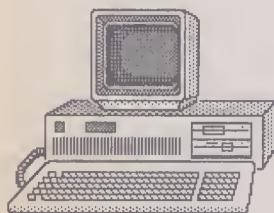
- Demoware. Demonstration programs for commercial or even shareware programs.
- Promoware. Software designed to promote a program, service, or other product.

If you've been wanting to try shareware but were afraid of catching a "computer virus" (a program that wreaks havoc in your computer, erasing or corrupting your data) you should know that most of the reputable shareware clearinghouses carefully monitor their programs. Seldom do computer viruses creep by. For your own protection, however, you should be on the lookout for viruses yourself.

The best medicine against a virus is to prevent it from entering your computer in the first place. This requires that you buy virus detection software. Most shareware companies offer at least one public domain anti-virus program. You may need to use several programs to protect your computer against any virus plague that threatens you.

UPGRADING AN OLD PC

Breathing new life into a vintage machine



Has the old computer you bought years ago has outlived its usefulness. Here's how to turn an 8088MHz weakling into a power users dream machine. You might still be using your old PC, or you may have replaced it with a newer model, keeping the

aged computer as a backup. But increasingly, you find the vintage PC just isn't useful for anything: it's slow, its memory limits it to running simple applications, and it lacks the power to use the latest software.

Yet like an older home, you can "remodel" that timeworn computer of yours and breath new life into its circuits. While you can go overboard and spend more on refurbishing your computer than buying a new one, with just a few hundred dollars and a bit of effort, you can upgrade your old PC or clone to give it a new lease on life. Whether you plan on keeping your modernized PC as your main computer, or consign it to a spouse, kids, or special application at work, you'll be rewarded with faster computing and greater efficiency, plus the ability to run a greater variety of software.

More Memory

The first enhancement you may want to consider is adding more memory to your computer. If your machine has less than 512K of RAM, it's a good candidate for more memory.

The exact design of your computer will dictate the way the memory is added, but in most cases, you'll need only to plug in extra RAM chips (and perhaps removing some others to make room). On the older-style IBM PCs and early clones, expanding the memory beyond 256K required the use of a separate memory card. The extra memory (up to 512K or 640K) is added to the card, rather than directly on the computer.

Even as recent as a year ago, prices for memory chips were steep; now the price is better than reasonable. Assuming your computer already has 256K of memory, upgrading it to the full

complement of 640K costs under \$100.

The basic memory limitation of PCs and clones is 640K, but that's for "base" memory — the memory used by the computer and most of your programs. Extra memory, called expanded or extended memory, can be added to allow your computer to handle very large programs and documents. You can add megabytes of extra memory to your computer, but your software must be able to access it. Check the manual to see how the program uses extended and expanded memory before you invest in copious amounts of RAM.

More Powerful Engine

Your computer is built upon a microprocessor, the electronic brain the controls the flow of data. In many ways, the microprocessor is like an engine in a car: with a slow engine, your software runs sluggishly. You may not always notice the inefficiency, especially if you never use a faster computer. But try your software on a more modern computer, and the difference in speed can be phenomenal.

If you have an old IBM PC, XT, or clone, you can easily exchange the microprocessor for a faster one. The NEC V-20 chip is a direct replacement of the Intel 8088 microprocessor used in the PC and XT, yet it helps increase the speed of the computer by 10 to 30 percent. Price is under \$10. The V-20 chip is sold at many electronic stores, and through mail order (check current issues of magazines such as Computer Shopper and PC Magazines for mail order firms carrying computer components).

An even better approach is to replace the entire motherboard of the computer. This board contains the microprocessor, the memory, and all the supporting electronics that make the computer run. Cost is a lot less than you'd expect: you can purchase a replacement "turbocharged" PC/XT motherboard for your computer for under \$100 (price does not include memory chips). The turbocharged motherboard runs about twice as fast as the motherboard in your old clunker. You need a screwdriver and a pair of pliers to swap the boards — no soldering or rewiring is required. Get a knowledgeable friend to help if you're afraid of the insides of computers.

Note that replacement motherboards are designed to fit the original IBM PC, XT, and the numerous generic clones that are based on the original IBM product. Replacement motherboards may not work with those PC-compatibles that use unique designs, such as the Kaypro, Sanyo, and Compaq. The board may not fit into the case, or may have different electrical requirements.

Add a Hard Disk

While you're upgrading the memory and microprocessor (or motherboard) of your computer, give some thought to data storage. Increasingly, software programs are requiring the use of hard disk drives. The size of the drive is not as important as just having one.

You can get by with an inexpensive 20 or 30 megabyte hard drive for your computer, and the cost — if you do some serious shopping — won't be over \$350. Used and refurbished hard drives cost even less, but you should know what you're getting before you buy.

Upgrading Your Display

More and more programs are going graphic. Your display adapter and monitor should be capable of displaying graphics,

either in black and white (monochrome) or color. If you already have the standard monochrome TTL monitor connected to your computer, you can add graphics capability for under \$50. You need to exchange the non-graphics display adapter already in your computer with one capable of Hercules graphics (so named after the company that popularized the monochrome graphics standards). You can use the same monitor.

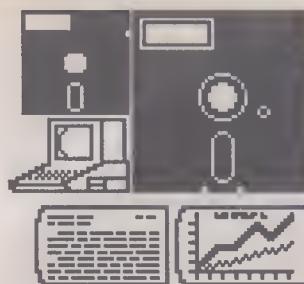
If you have color, and it's the older CGA graphics standard, you may want to consider investing in EGA or VGA graphics. You get more colors and the resolution of the display is far better. In the case of exchanging color displays you need to invest in a new monitor — that alone can set you back \$300 to \$500, depending on the model and its capabilities. And you need to purchase a new display adapter, which can cost \$150 to \$300.

A less expensive route is to purchase a VGA graphics adapter (under \$150 mail order), and a "paper-white" VGA monochrome monitor, at a cost of about \$200 to \$250. Even though the graphics adapter is capable of color, you see only black and white (you can always add a color monitor later, if you want). The image appears as black characters on a white background, and is ideal for word processing and desktop publishing.

Other Improvements

You can make other significant improvements to your computer. Remember: keep an eye out for mounting costs. At a certain point it may be cheaper to invest in a new computer, and let the old one out to pasture. But as long as you're keeping within your budget, consider:

- Upgrading the power supply with a more powerful unit. This may be necessary if you're adding a large hard disk drive (say, over 80 megabytes), or a lot of other internal accessories. A 200 watt power supply costs about \$65.
- Add an internal modem, and call other computers over the phone line. The internal modem connects into one of the empty expansion slots inside your computer, so it doesn't take up any desk space. You can get good-quality 1200 or 2400 bit-per-second modems for under \$125.
- Get a newer version of DOS, the PC's disk operating system. As of this writing, you have your choice between version 3.3 or 4.01. Unless you plan on creating elaborate menu systems or operating very large hard disk drives, you can opt for version 3.3; many users insist it's less "buggy." Cost for the software is about \$75; even less if you shop around.
- Add a mouse. The mouse is an alternate input device that's supported by a growing number of programs, including WordPerfect and Microsoft Word. Instead of pressing keys you control the program by pushing the mouse around the table. The average mouse costs \$75 to \$125. Spend \$10 extra for a mouse pad, to prevent marring your table.



ing your work at home. Junior can use it for week nights for homework, and the little ones can use it for playing games.

But with the computer home and set up, what now? Does anyone know how to really use the thing? Even turning it on seems to require monumental knowledge of computers. The kids seem to get the idea quickly — they're fast learners after all — but the thicker skulls of the grownups need extra help.

If you feel you need a course on computer literacy and operations, take heed: an education in computers is but a class, book, magazine, seminar, or videotape away. Whether you're trying to learn the basics of MS-DOS for your PC clone, or the intricacies of PageMaker for desktop publishing, you'll find someone or something that teaches it.

Reading the Manual

Your basic education in all computer matters starts with the manual. All computers and programs come with manuals, but not all are written to be understood. Some "manuals" are mere skeletons providing nothing more than specifications and an overview of operation. You're on your own when it comes time to actually use the thing. A few manuals — particularly those that accompany imported PC clone component parts — aren't even written in English.

By far, though, name brand computers and commercial software comes with readable and understandable manuals. Look to these manuals first when learning about a new computer or program. If you think you still need more help, then you can graduate to a book or magazine, or perhaps a class that specializes in the hardware or software you own.

Books and Magazines

If the manual that accompanies your computer or program assumes a greater knowledge of computers than you have, you may wish to bone up on the basics first. Books and magazines provide the least expensive and most convenient relief.

Magazines tend to be specialty-oriented: don't buy PC Magazine if you own a Macintosh. Likewise, BYTE magazine is written for the advanced computer user, while PC Computing, and Home/Office Computing are geared toward first-timers. Other magazines — like Computer Buyer's Guide & Handbook, are geared towards serious shoppers, particularly those who do a lot of mail order buying.

Spend a few moments at the newsstand flipping through the current issues. You're bound to find how-to and informational articles that will bolster your understanding about computers. Don't be afraid to buy more than one magazine.

If the short articles in magazines aren't enough for you, try books. Books form the backbone of computer literacy, and even if you take a class or seminar on computers (see below) the reference material used in the class will — in all likelihood — be a book.

When in the market for a computer book, go to a regular bookstore, such as B. Dalton, Waldenbooks, or Crown. With the exception of software-only chains, namely Software Etc. and Egghead, computer stores don't stock computer books.

LEARNING ABOUT COMPUTERS

If you feel the need to know more

So you've just spent \$1,500 on a new computer. You figure the investment is well worth it: you'll use it a few times a week for tracking the family's finances, writing letters, and for finish-

As with magazines, you'll find books on most any computing subject. Beginner's books are harder to find these days, because the market turns up its nose at them. The title isn't always demonstrative of the level of the book. Look for titles like "A-B-C's of WonderWare," or "First Book of the Edsel Computer." Usually — but not always — beginner's books average about 350 pages; the typical intermediate- to advanced-level books can contain 600 or more pages.

If you're not sure which book you should get, ask. Be sure to mention you're looking for a beginning-level book.

Schools and Seminars

To many, reading manuals, books, and magazines is the slow road to mastering computers; they need a faster education and prefer the human touch of a school or seminar.

Most every community has at least one adult-education school that offers classes on computers. A good place to start is the local junior college or high school (a state-funded college is another option). Ask if they offer continuing education courses on computers. Private continuing-education schools — located primarily in larger cities, are yet another alternative. Look in the phone book or ask at the reference desk at your local library.

Some computer stores offer classes as a side-line business. Beware of the computer store class that's merely a marketing gimmick. And finally, look in the classifieds for private individuals that offer one-on-one classes.

When you locate a class you might be interested in, ask for an outline of the course. If there's no outline, the teacher may not be well prepared, and the class may suffer from it. Look over the outline to see if the class covers the material you need.

The cost of classes varies from as little as free to well over \$200 for day-long discourses on business software. Obviously, the higher the cost, the more careful you'll want to be when selecting a class.

Computer seminars offer a more structured approach to learning about computers. Seminars are generally aimed at the business person who must develop a new computer skill for work. Few seminars are on basic hardware topics (no "this is how to turn on your computer"), but rather concentrate on business software like WordPerfect, Lotus 1-2-3, and dBase.

Cost can be considerable — \$500 or more for a two day jaunt. If you're looking for a seminar, it can prove difficult to find: most seminar organizers advertise by direct mail. Most mailing lists are developed from magazine subscriptions. If you're not on the seminar mailing lists, ask friends and associates to be on the lookout for you, and save the marketing flyers they get in the mail.

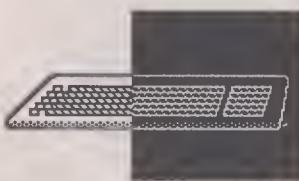
Videotapes

The latest educational craze is videotape. Instead of reading and doing, you watch and do. The advantage of videotape is that the picture shows a visual step-by-step example. The narration guides you along and serves as reinforcement. The disadvantages are that videotapes are expensive — \$30 to \$60 per tape is the norm — and they cover basics only.

Some computer-oriented videotapes are sold by some software-only retailers, but most are available mail order. Pick up a recent copy of a PC Magazine (or most any other magazine, for that matter), and leaf the pages for videotape teaching ads. You'll find most of the ads near the back in the display classifieds.

SIX STEPS TO A HEALTHY KEYBOARD

How to keep keep clicking away.



Picture this: You're busy writing a proposal for your best client when you accidentally spill coffee into the keyboard. While there's no Fourth of July fireworks display in your office, the keyboard is immediately rendered inert; the coffee has shorted the keys and your computer now acts dead to the world. You meekly tap out H-E-L-P on the keyboard, but nothing appears on the screen. Don't despair — All may not be lost. While you can always replace the keyboard for \$75 or \$100 (and sometimes more), you may be able to repair the damage yourself. All it takes is a screwdriver, a paper towel or two, and a couple of other cleaning supplies.

Be aware that disaster — like spilled coffee, or any other beverage — doesn't need to strike before your keyboard needs medical attention. Over time, the electrical contacts in keyboards can become dirty or contaminated, rendering some or all of the keys inoperative. A simple cleaning can rejuvenate your keyboard, saving you the cost of having it repaired or replaced.

Let's take a closer look at the six steps to a healthy keyboard. You'll learn how to diagnose problems, how to disassemble the keyboard, and how to carefully clean the keys.

1. Assess the Damage

Before you attempt to repair or clean your computer's keyboard you should assess the damage. If the keyboard is suddenly acting up, without any indication of rough use, first suspect your computer, software, or keyboard cable. Reset your computer or better yet, turn it off, wait a few seconds, then turn it back on again. Occasionally that will clear up the problem.

Be sure your software isn't the root of the difficulty. Some programs change the characteristics of the keyboard — even to the point of re-assigning keys. If your software lets you "re-map" the keys on your keyboard (switch the letters A and S, for example), turn the alternate keyboard assignment off, or reset your computer.

Check that the keyboard cable is firmly seated in the connector at the back of the computer. You may need to turn the computer off, remove the cable, and clean the connectors. For cleaning, use any non-residue electrical cleaner, available at Radio Shack and most electronics parts stores. Dust and dirt can inhibit proper electrical connection, and that could cause your keyboard to operate unpredictably.

If your computer, software, and keyboard connector seem fine, you can suspect the keyboard. Look for signs of damage or foreign objects. TURN THE COMPUTER OFF and turn the keyboard upside down. Does anything fall out? If the computer has been used for any length of time, dust, dirt, and other crud can get caught under the keys. A light tapping on the back of the keyboard will often loosen the debris. For a heavy-duty cleaning job, clean the keys using a strong vacuum

equipped with a soft brush attachment.

2. Disassemble the Keyboard

Assuming your efforts at fixing the keyboard haven't been successful, it's now time to disassemble the keyboard and work at the problem from the inside out. But first, a word of CAUTION: Taking your keyboard apart may void its warranty. If the keyboard or computer is still under warranty, you will probably want to return it to your dealer's for repair.

Most keyboards currently used on PCs and clones share similar engineering: most are constructed with a single, large printed circuit board. This circuit board contains few integrated circuits or other electrical components, but mainly consists of contact points for each of the keys on the keyboard.

Each key is composed of a plastic key top, a spring-loaded plunger, and a spongy-foam backed with a piece of metal foil. When you press a key, it pushes the metal foil against the contact point on the circuit board. That tells the computer that a key has been struck. Release the key and it springs back up, disengaging the electrical contact.

Only the expensive, high-end keyboards use individual electrical switches for each of the keys. These switches are usually sealed against outside contaminants, but they are not water-proof — or cigarette-smoke proof. If your keyboard uses individual switches instead of the foam-metallic contactors, you may need to replace the defective switches. This process is beyond the scope of this article.

Begin disassembly by turning the computer off and disconnecting the keyboard from the back of the computer. Perform your surgery only in a well-lit area. Spread a soft cloth on the table to protect the keyboard and work surface, and be sure to save all parts as you remove them.

Temporarily touch a grounded metal object — the bare-metal case of your computer is a good choice. This helps drain the static electricity of your body, which reduces the chance of damage to the integrated circuits used in the keyboard.

Turn the keyboard over and locate the screws. Depending on the keyboard, you will find four to eight screws, all recessed within the bottom cover. Remove them all. Set the screws aside (use a dish to keep the screws in one place), and remove the top half of the keyboard case. The keyboard itself will remain attached to the lower half of the keyboard case.

Turn the keyboard over (rightside up) and remove the four screws that attach the keyboard frame to the case. Save these in a separate bowl.

Turn the keyboard over once more and locate the screws positioned along the back of the printed circuit board. There should be 18 to 24 of these screws, positioned at strategic points on the board. As these screws are rather small, you may need a jeweler's screwdriver to remove them. Take care not to strip the top of the screw, or you'll never be able to remove it. As before, save these screws in a separate bowl.

3. Brush Out the Keyboard

When all the screws are removed, carefully lift the circuit board up to expose the underside of the keys. You'll see the foil-capped sponges under each key. Watch for loose parts, such as a sponge that has been disengaged from its key top.

Wipe the excess litter from the insides of the keyboard with a soft brush. If you spilled liquid into the keyboard, soak it up with a couple of paper towels. Water and diet sodas do the least amount of damage. These usually evaporate with little or



no tell-tale trace. But coffee, tea, milk, and sugar-based drinks leave a residue that must be cleaned.

4. Clean with Alcohol or Cleaner

Wet a paper towel with isopropyl alcohol, and wipe the dust, debris, and residue from the electronic contacts on the printed circuit board. The contacts should be bright and shiny. Throw the towel away when you are done.

If you're cleaning spilled liquid, and that liquid has dried and is caked on, you may need to apply some electrical contact cleaner, available at Radio Shack (as well as most electronics outlet stores; look under Electronics-Retail in the Yellow Pages for electronics dealers near you). Be sure to get the kind of cleaner that leaves no residue or lubricant. NEVER use a cleaner/lubricant such as LDS or WD-40, as this will leave a non-conductive film inside the keyboard, rendering it useless.

Unfortunately, most electrical contact cleaners use hydrofluorocarbons (specifically Freon), which have been found to disrupt the ozone layer of the Earth's atmosphere. So use this stuff sparingly.

Pour some isopropyl alcohol in a clean ceramic dish. Dip a cotton-tipped swab, such as a Q-Tip, into the dish, and carefully clean the metal foil on each key. Be careful that you don't pry the foil or sponge off, otherwise you'll have to glue them back into place. You can use ordinary white glue, but apply just a dab. DO NOT apply any glue on a contact surface — either foil or the printed circuit board — as this will impair the function of the keyboard.

After cleaning is complete, leave the keyboard open for three to five minutes, to allow the alcohol to completely evaporate. Then, replace the circuit board, being careful to position the board correctly over the key tops. Reassemble the keyboard in the reverse sequence as you took it apart. Be sure to replace ALL screws. If you lose a screw, replace it with another. Do not omit it.

5. Key Top Repair

Not all repairs require that you take the entire keyboard apart. If you loose or break a key top, you can replace it with a part from a discarded keyboard. You can often find old keyboards at computer swap meets and surplus electronics stores. Or, you may have one stashed in a closet or garage someplace. Use a medium flat-bladed screwdriver to pry up the keytop. Apply even pressure to avoid cracking or breaking the plastic. Press

the new key top into place, and check to be sure that the key springs back into position after you press it. If the key doesn't spring back, the keyboard will not work properly.

6. Testing the Keyboard

When the keyboard is properly re-assembled, reconnect it to your computer and turn the machine on. Most computers include a power-on test that will warn you if the keyboard is not functioning properly. If this warning appears, turn the computer off and inspect your work.

Assuming the keyboard passes the power-on test, wait until the computer displays the DOS prompt, then press every key. Look for characters that don't appear when you press their corresponding keys, or keys that "stick" and print a row of characters on the screen. For a more thorough job, obtain a keyboard testing program from a public domain or Shareware clearinghouse, such as PC-SIG.

PROTECTING YOUR COMPUTER

Strategies for an important investment.



and airborne dirt — but by burglars? Not an hour passes that someplace, somewhere in this country an expensive computer is stolen, and with it days, weeks, perhaps months of work. Adding insult to injury, a stolen computer prevents you from doing your work, until you get a replacement or are lucky enough to locate your original computer.

As with anything else you own, taking just a few moments to review the security of your computer goes a long way to making sure it stays on your desk.

Bolt in Down

The majority of computer are used in offices. The current trend in office design these days is open space planning, meaning that a number of computers are just sitting out in the open. Compounding the problem is that many offices employ janitorial services that come in during the evening hours. While these janitorial services are bonded and insured, that doesn't mean thefts never occur. Suites in office buildings are prone to the same problems, and these use a janitorial and maintenance crew hired by the building management. You have little say in who enters your office, or when.

The best way to protect your computer in an office is to physically attach the machine to the desk. This isn't as ridicu-

lous or difficult as it may sound. Locks and tie-downs are often used in public libraries to protect their computers. A number of locks are available; consult your local dealer for more information.

If the design of your office can accommodate it, place your computers in rooms that can be individually locked. The locks should not use the same master key as the main entry door.

Whether you hire your own maintenance crew, or use the one provided by the building management, be sure you know who will be in your offices and the scheduled clean-up time. If you have a great deal of valuable computer equipment — say over \$100,000 worth — you may wish to install a security system for added protection. The security system should be connected to a service, rather than simply sound a bell in the office building. No one may be around to hear it. The maintenance crew will need to be able to work around the security system, which will require them to enter and vacate the area at prescribed times.

If you use your computer at home, you'll want to protect it with the same care and diligence as you protect your other belongings. Avoid telling everyone in your neighborhood that you have the latest Super-Duper 386SX Computer; the news may eventually reach the wrong ears. And be sure to keep your doors and windows locked tight when you leave the house.

Back Up Data

There's no way to stop a determined thief. If your computer is the target of a burglary, a good thief will be able to snatch it up before the police can arrive. Assuming the worst, you should prepare for the eventuality by always making backups of the data on your hard disk. Should your computer be stolen, your programs and data can be safely restored onto a another computer. Without the backup, you stand to lose a considerable amount of work.

For hard drives under 40 megabytes, the old-fashioned floppy disk backup is satisfactory. A backup program like PC Tools Backup (part of the PC Tools Deluxe package), Fast-back, or Back-It makes the process easier. You'll need a few dozen diskettes, which you can recycle as you make new backups.

It is inconvenient to use diskettes for backing up the data on hard drives larger than 40 megabytes. This inconvenience will mean you simply won't take the time to do it, and that can lead to potential trouble. One of the fastest and most efficient methods of backing up large hard disks is using a streaming tape drive. Pop a tape cassette into the drive, then run the backup software. Everything is taken care of for you and the backup can be completed unattended. A streaming tape drive, which is about the same size as a floppy disk drive, costs about \$350, depending on the model.

Insuring Your Computer

Let's say you've just been robbed and your computer is gone. Your first call should be to the police, to report the theft. Your second call should be to your insurance company, so you can enter a claim. But are you sure your insurance policy covers your computer? Don't be too quick to answer yes.

Most insurance policies for businesses include computers in the general business equipment rider. This rider should cover fax machines, typewriters, telephone, and computers. But some insurance companies are little behind the times, and may specifically exclude computers from their coverage, based on

their high replacement cost. The moral: read your insurance policy carefully. If you have any questions, contact your agent.

Insurance Riders

In the home, computers used for work are generally **not** covered by your homeowner's or contents insurance. That means that if you run a business out of your home, and use a computer to conduct that business, the insurance company probably won't cover it. For full coverage, you'll need a special rider from your insurance company. This rider costs extra and specifically includes your computer gear. The cost of the rider varies depending on the insurance company, your location, and the amount covered, but you should expect about \$150 to \$250 per year for \$5,000 of computer equipment.

Most insurance companies cover replacing the hardware only. Software is seldom included, and never your time and effort in entering the data. For more comprehensive coverage, you may want to consider a specialty insurance policy, such as that available from Safeware (2929 N. High St., PO Box 02211, Columbus, OH 43202; 800/843-3469). For a rather modest fee, Safeware will insure your hardware, software, and data against theft, fire, and other accidental damage.

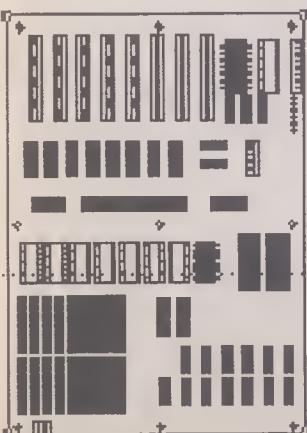
Photographing the Evidence

Before disaster strikes, you should photograph your computer equipment. This documents it for the police and your insurance company. You don't need anything fancy: a clear, sharp snapshot is fine. A Polaroid instant camera works wonders. But a pack or two of film and photograph everything you own, including the computer, printer, modem, monitor, and software. If you have a close-up lens, take a snap-shot of the back of your equipment and the serial number displayed there.

Of course, a photograph alone probably won't satisfy your insurance company in the case of theft or other damage. You'll need receipts documenting that you bought the gear in the first place. Make copies of these receipts and store them in a safe place, preferably not in the same house or office as the computer. In the case of fire, you could lose your computer, **and** the receipts.

USING A TURBO MOTHERBOARD

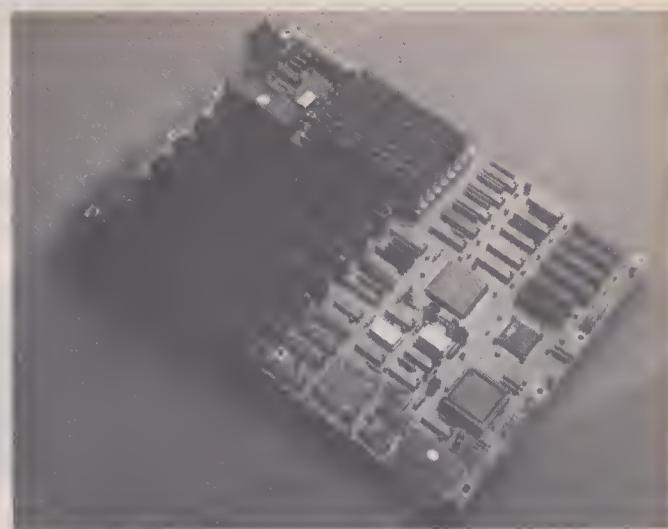
For fast processing and operations



So-called "turbo" motherboards have a operating clock frequency in excess of the standard MHz clock used in the PC/XT and AT clones. The increase in clock speed makes certain programs and computer operations go faster.

Two Speeds

Turbo motherboards actually have two speeds: In the case of the PC/XT, the base speed is 4.77 MHz, and the turbo



Motherboard Suppliers

A+ Computer, Inc.	(800) 443-5373
Adtech	(800) 326-6548
All Tex Electronics, Inc.	(800) 531-5369
JDR Microdevices	(800) 538-5000

speed is generally 8, 10, and sometimes 12 MHz. AT-class compatibles operate at a "normal" speed of 12 MHz or faster, but also provide a slow-mode of 8 MHz. The slower rate helps maintain compatibility with certain software programs (like games) that are sensitive to clock speed, and the faster speed helps you get your work done faster.

ROM BIOS

The ROM BIOS is used to switch the motherboard between normal and turbo speeds. The BIOS either does this automatically, sensing when the speed needs to be adjusted (during boot up, disk operations, etc.), or under control by you.

With most all turbo motherboards, you alternate between high and low speeds by pressing the following keys:

Switch to	Press
Slow	Ctrl-Alt-(minus)
Turbo	Ctrl-Alt-(plus)

Be sure to press the minus and plus keys on the keypad, NOT the ones to the immediate right of the zero (0) key. Usually, when in high speed mode, the flashing cursor will be a large block, instead of a slender line. This tells you that the computer is in turbo mode. Also, many XT and AT clones use an LED on the case of the computer to indicate turbo mode.

In addition, a jumper on the motherboard sets the default operating speed. Typically, if the jumper is present, the motherboard defaults to "slow" speed. If the jumper is missing, the motherboard defaults to "turbo" speed. Your turbo motherboard may be different than the one described here. If so, consult the operations manual that came with it.

Street Price Guide

A directory of the lowest prices nationwide.



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The Street Price Guide

Editors of The Street Price Guide regularly scan the country for the lowest prices available within each product category. This includes monitoring newspaper and magazine advertisements, and maintaining an ongoing phone dialog with outlets around the country. At press time, the computer selects the lowest prices for each category. Due to the lead time necessary for this issue to reach newsstands (several weeks), and the volatile nature of the discount marketplace, prices can fluctuate marginally up or down.

HARD DISK DRIVES

MAKE/ MODEL	CAPACITY (Mb)	SPEED (ms)	CONTROLLER	STREET PRICE	DEALER	MAKE/ MODEL	CAPACITY (Mb)	SPEED (ms)	CONTROLLER	STREET PRICE	DEALER	
ESDI												
Fujitsu						CP 3184	80	25	Y	419	Advanced Computer	
M 2263E	690	16	N	1,439	MegaHaus Drives	CP 3204	210	16	N	569	Access Computer Tech.	
M 2263E	690	16	N	1,499	Storage Devices, Inc.	CP 3204	210	16	Y	610	California Microchip	
M 2263E	690	16	Y	1,589	DC Drives	CP 3204	210	16	N	635	Computer Products Corp.	
Maxtor						CP 3204	210	16	N	649	ET Valueline	
8760E	660	16	Y	1,495	JB Technologies	CP 3204	210	16	Y	669	Hard Drives International	
8760E	660	16	N	1,539	Storage Devices, Inc.	K/Lok	KL 343	40	28	N	149	Warehouse 54
8760E	660	16	Y	1,549	Computer Products Corp.	KL 343	40	28	N	189	Advanced Computer	
8760E	660	16	Y	1,699	Hard Drives International	KL 343	40	28	Y	209	MegaHaus Drives	
Micropolis						Maxtor	7040A	40	18	Y	199	Computer Products Corp.
MC 1518	1346	14	N	2,595	FastMicro	7040A	40	18	N	209	Hard Drives International	
MC 1518	1346	14	Y	2,679	DC Drives	7040A	40	18	N	209	Storage Devices, Inc.	
MC 1518	1346	14	N	2,875	JB Technologies	7080A	80	18	Y	299	Computer Products Corp.	
MC 1568	670	15	N	1,499	FastMicro	7080A	80	18	Y	319	Hard Drives International	
MC 1568	670	15	N	1,578.65	Computer Disc. Whse.	7080A	80	18	N	349	Soft Hard Systems	
MC 1568	670	15	Y	1,749	Hard Drives International	MiniScribe	8051A	40	28	N	169	Under-Ware Electronics
MC 1568	670	15	N	1,799	Soft Hard Systems	Quantum	LPS52A	50	17	N	205	CompuAbility
MC 1664	345	14	N	1,099	FastMicro	LPS52A	50	17	N	239	Computer Products Corp.	
MC 1664	345	14	Y	1,149	DC Drives	LPS52A	50	17	Y	269	MegaHaus Drives	
MC 1664	345	14	N	1,225	Soft Hard Systems	Rodime	R3139	110	18	N	349	Under-Ware Electronics
MC 1664	345	14	Y	1,299	Hard Drives International	R3139	110	18	N	355	Storage Devices, Inc.	
Seagate						R3139	110	18	N	369	Treasure Chest	
ST 2182E	160*	16	N	879	Computer Products	R3259	210	18	N	559	Storage Devices, Inc.	
ST 2182E	160	16	N	889	Storage Devices, Inc.	R3259	210	18	N	579	Treasure Chest	
ST 2182E	160	16	N	979	Hard Drives International	R3259	210	18	N	599	Under-Ware Electronics	
ST 4383E	330	18	N	1,159	Computer Products	Seagate	ST 1102A	85	19	N	284	Computer Products Corp.
ST 4383E	330	18	N	1,169	Storage Devices, Inc.	ST 1102A	85	19	N	299.95	Computer Direct	
ST 4383E	330	18	N	1,199	Advanced Computer	ST 1102A	85	19	Y	309	USA Flex	
ST 4766E	660	15	N	1,395	Computer Products Corp.	ST 1144A	120	19	Y	379	Quick Electronics	
ST 4766E	660	15	N	1,475	Storage Devices, Inc.	ST 1144A	120	19	Y	389	Computer Products Corp.	
ST 4766E	660	15	N	1,499	Advanced Computer	ST 1144A	120	19	Y	419	USA Flex	
Toshiba						ST 1162A	140	15	N	409	Advanced Computer	
MK 358FA	675	14	N	1,399	Advanced Computer	ST 1162A	140	15	Y	569	Computer Products Corp.	
MK 358FA	675	14	N	1,439	Storage Devices, Inc.	ST 1162A	140	15	Y	615	USA Flex	
IDE												
Conner						ST 1201A	175	15	N	549	MicroLab	
CP 3044	40	25	N	229	MidWest Computer	ST 1201A	175	15	Y	619	USA Flex	
CP 3044	40	25	N	245	Computer Products Corp.	ST 1239A	210	15	N	599	Computer Products Corp.	
CP 3044	40	25	Y	269	California Microchip							
CP 3184	80	25	N	369	Soft Hard Systems							
CP 3184	80	25	Y	379	Hard Drives International							

For dealer addresses and phone numbers see page 78

NA denotes not available

* For further explanation see Street Price Buying Tips

STREET PRICE GUIDE: HARD DISK DRIVES

MAKE/ MODEL	CAPACITY (Mb)	SPEED (ms)	CONTROLLER	STREET PRICE	DEALER	MAKE/ MODEL	CAPACITY (Mb)	SPEED (ms)	CONTROLLER	STREET PRICE	DEALER
ST 1239A	210	15	N	629	Treasure Chest	Seagate					
ST 1239A	210	15	N	629	USA Flex	ST 238R	30	65	Y	178	Storage Devices, Inc.
ST 157A	45	28	Y	177	Computer Products Corp.	ST 238R	30	65	N	179	Advanced Computer
ST 157A	45	28	Y	179	Quick Electronics	ST 238R	30	65	Y	184.95	Lyco Computers
ST 157A	45	28	Y	198	USA Flex	ST 238R	30	65	Y	213	Treasure Chest
ST 2274A	240	16	Y	1,129	USA Flex	ST 277R	65	28	N	247	DC Drives
ST 2274A	240	16	N	1,198	Storage Devices, Inc.	ST 277R	65	28	N	247	Storage Devices, Inc.
ST 2383A	340	16	N	1,135	Storage Devices, Inc.	ST 4144R	120	28	N	548	Storage Devices, Inc.
ST 2383A	340	16	Y	1,149	Computer Products Corp.	ST 4144R	120	28	Y	589	Computer Products Corp.
ST 2383A	340	16	Y	1,159	USA Flex	ST 4144R	120	28	Y	594	DC Drives
Toshiba						SCSI					
MK 234F	105	23	N	349	FastMicro	Fujitsu					
MK 234F	105	23	N	379.99	Tredex	M 2261S	355	16	N	1,199	Quick Electronics
MK 234F	105	23	N	429	Warehouse 54	M 2261S	355	16	N	1,239	DC Drives
Western Digital						M 2261S	355	16	N	1,239	MegaHaus
WD 93044	40	28	N	159	U \$ave	M 2263S	670	16	N	1,459	Quick Electronics
WD 93044	40	28	N	165	Miracle Computers	M 2263S	670	16	Y	1,589	Storage Devices, Inc.
WD 93044	40	28	N	209	JB Technologies	M 2263S	670	16	Y	1,598	DC Drives
MFM						Maxtor					
K/Lok						8380S	360	16	Y	1,179	Computer Products Corp.
KL 320	20	40	N	119	MicroLab	8380S	360	16	Y	1,299	DC Drives
KL 320	20	40	N	139	Warehouse 54	8380S	360	16	Y	1,299	Hard Drives International
KL 320	20	40	N	169	Hard Drives International	M 2263S	670	16	N	1,459	Quick Electronics
Mitsubishi						M 2263S	670	16	Y	1,589	Storage Devices, Inc.
MR535	40	28	N	225	Storage Devices, Inc.	M 2263S	670	16	Y	1,598	DC Drives
MR535	40	28	Y	244	DC Drives	Quantum					
MR535	40	28	N	259	Hard Drives International	LPS105S	105	19	N	359	ComputAbility
Seagate						LPS105S	105	12	N	389	Computer Products Corp.
ST 1100	80	15	N	569	DC Drives	LPS105S	105	12	N	519	DC Drives
ST 1100	80	15	N	575	Storage Devices, Inc.	LPS52S	50	17	N	249	Computer Products Corp.
ST 1100	80	15	N	579	Hard Drives International	LPS52S	50	17	N	249	Storage Devices, Inc.
ST 1100						LPS52S	50	17	Y	379	DC Drives
ST 225	20	65	N	165	Advanced Computer	PRO210S	210	15	N	679	ComputAbility
ST 225	20	65	N	169	Storage Devices, Inc.	PRO210S	210	15	N	695	Advanced Computer
ST 225	20	65	Y	177.95	Lyco Computers	PRO210S	210	15	N	699	Computer Products Corp.
ST 251-1	40	28	Y	219	Computer Products Corp.	Seagate					
ST 251-1	40	28	N	219	MicroLab	ST 1480N	425	14	N	1,265	Quick Electronics
ST 251-1	40	28	Y	228.95	Lyco Computers	ST 1480N	425	14	N	1,299	DC Drives
ST 251-1	40	28	N	235	Minuteman Computers	ST 1480N	425	14	N	1,329	MegaHaus
ST 4096	80	28	N	445	Storage Devices, Inc.	ST 296N	85	28	N	269.95	Lyco Computers
ST 4096	80	28	N	469	DC Drives	ST 296N	85	28	Y	289	Computer Products Corp.
ST 4096	80	28	Y	509	Computer Products Corp.	ST 296N	85	28	N	289	Storage Devices, Inc.
RLL						ST 41200N	1050	16	N	1,999	ComputAbility
K/Lok						ST 41200N	1050	16	Y	2,049.95	Lyco Computers
KL 330	30	40	N	129	MicroLab	ST 41200N	1050	16	Y	2,119	DC Drives
KL 330	30	40	N	139	Hard Drives International	ST 41200N	1050	16	N	2,159	Storage Devices, Inc.
KL 330	30	40	N	149	Warehouse 54	ST 41650N	1650	15	N	2,559	Storage Devices, Inc.
MiniScribe						ST 41650N	1650	15	Y	2,599	DC Drives
8450	40	45	N	169	JB Technologies	ST 41650N	1650	15	N	2,699	Treasure Chest
Mitsubishi						ST 41650N	1650	15	N	2,875	JB Technologies
MR535	60	28	N	225	Storage Devices, Inc.						
MR535	60	28	Y	244	DC Drives						
MR535	60	28	N	259	Hard Drives International						

FLOPPY DISK DRIVES

MAKE/ MODEL	MOUNT- ING	STREET PRICE	DEALER	MAKE/ MODEL	MOUNT- ING	STREET PRICE	DEALER
3.5/DOUBLE DENSITY							
Chinon		49.95	Lyco Computers	Toshiba		59	MicroLab
Chinon		50	Quick Electronics	Toshiba		67	Advanced Computer Products
Chinon		51	MidWest MicroPeripherals	Toshiba		67	ComputAbility
Toshiba				Toshiba		69	Arlington Computer
Mitsubishi		89	Swan Technologies	Toshiba		79	MidWest Computer Works
5.25/DOUBLE DENSITY							
Mitsumi		46	Syntax	Chinon		49	Quick Electronics
Sony		59	ET Valueline	Chinon		54.95	Lyco Computers
Sony		69	Swan Technologies	Mitsumi		44	Syntax
Teac		59	DC Drives	Teac		54	Warehouse 54
Teac		59	Warehouse 54	Teac		57	Advanced Computer Products
Teac		62	Advanced Computer Products	Teac		57	DC Drives
Teac		65	Minuteman Computers	Teac		59	Minuteman Computers
Teac		72.95	Computer Direct	Teac		59	Telemart
Toshiba		59	Advanced Computer Products	Teac		66.95	Computer Direct
Toshiba		59	ComputAbility	Teac		69	MidWest Computer Works
Toshiba		69	Arlington Computer	Toshiba		54	Advanced Computer Products
3.5/HIGH DENSITY							
Chinon		58	MidWest MicroPeripherals	Toshiba		59	Advanced Computer Products
Chinon		58.95	Lyco Computers	Toshiba		59	Bulldog Computers
Chinon		64	Hard Drives International	Toshiba		59	ComputAbility
Citizen		59	MidWest MicroPeripherals	Toshiba		59	Advanced Computer Products
Epson		53	California Microchip	Toshiba		59	Bulldog Computers
Epson		60	Silverado	Toshiba		59	ComputAbility
Epson		69.95	Ralin Wholesalers	Toshiba		59	Advanced Computer Products
Fujitsu		56	Aberdeen	Toshiba		59	Bulldog Computers
Mitsubishi		109	Swan Technologies	Toshiba		59	ComputAbility
Mitsumi		52	Syntax	Toshiba		59	Advanced Computer Products
Mitsumi		59	TSC Computer Products	Toshiba		59	Bulldog Computers
Mitsumi		65	SolidTech	Toshiba		59	ComputAbility
Mitsumi		69	Sunnytech	Toshiba		59	Advanced Computer Products
Sony		59	MidWest MicroPeripherals	Toshiba		59	Bulldog Computers
Sony		69	USA Flex	Toshiba		59	ComputAbility
Sony		79	Swan Technologies	Toshiba		59	Advanced Computer Products
Teac		59	MicroLab	Toshiba		59	Bulldog Computers
Teac		63	DC Drives	Toshiba		59	ComputAbility
Teac		65	FastMicro	Toshiba		59	Advanced Computer Products
Teac		70	Minuteman Computers	Toshiba		59	Bulldog Computers
Teac		72	Advanced Computer Products	Toshiba		59	ComputAbility
Teac		78.95	Computer Direct	Toshiba		59	Advanced Computer Products
Teac		79	Lucky Computers	Toshiba		59	Bulldog Computers
5.25/HIGH DENSITY							
Chinon		59	Quick Electronics	Toshiba		59	Advanced Computer Products
Chinon		59.95	Lyco Computers	Toshiba		59	Bulldog Computers
Chinon		64	Hard Drives International	Toshiba		59	ComputAbility
Epson		56	Aberdeen	Toshiba		59	Advanced Computer Products
Epson		57	California Microchip	Toshiba		59	Bulldog Computers
Epson		60	Silverado	Toshiba		59	ComputAbility
Epson		69.95	Ralin Wholesalers	Toshiba		59	Advanced Computer Products
Fujitsu		56	Aberdeen	Toshiba		59	Bulldog Computers
Mitsubishi		52	Syntax	Toshiba		59	ComputAbility
Mitsumi		57	TSC Computer Products	Toshiba		59	Advanced Computer Products
Mitsumi		65	SolidTech	Toshiba		59	Bulldog Computers
Mitsumi		69	Sunnytech	Toshiba		59	ComputAbility
Sony		59	MidWest MicroPeripherals	Toshiba		59	Advanced Computer Products
Sony		69	USA Flex	Toshiba		59	Bulldog Computers
Sony		79	Swan Technologies	Toshiba		59	ComputAbility
Teac		59	MicroLab	Toshiba		59	Advanced Computer Products
Teac		63	DC Drives	Toshiba		59	Bulldog Computers
Teac		65	FastMicro	Toshiba		59	ComputAbility
Teac		70	Minuteman Computers	Toshiba		59	Advanced Computer Products
Teac		72	Advanced Computer Products	Toshiba		59	Bulldog Computers
Teac		78.95	Computer Direct	Toshiba		59	ComputAbility
Teac		79	Lucky Computers	Toshiba		59	Advanced Computer Products

I = Internal E = External For dealer addresses and phone numbers see page 78

MONITORS: MULTISYNC, SVGA, VGA

MAKE/ MODEL	STREET PRICE	LIST PRICE	DEALER	MAKE/ MODEL	STREET PRICE	LIST PRICE	DEALER				
MULTISYNC MONITORS											
Cornerstone				Seiko							
DualPage	1,875	2,495	Publisher's Toolbox	CM 1440	475	899	Microcomputer Concepts				
DualPage	1,878	2,495	Publishing Perfection	CM 1440	499	899	Laser Press & Graphics				
DualPage 16GS	2,368	3,395	Publishing Perfection	CM 1440	499	899	Treasure Chest				
DualPage 16GS	2,379	3,395	Publisher's Toolbox	CM 1450	589	999	Treasure Chest				
XL Page Mono	919	1,295	Publishing Perfection	CM 1450	619.95	999	TriState Computer				
XL Page Mono	925	1,295	Publisher's Toolbox	CM 1450	629	999	Microcomputer Concepts				
Hitachi				CM 2050	1,799	2,999	Treasure Chest				
CM 1483	399	799	MicroProfessionals	CM 2050	1,999	2,999	Laser Press & Graphics				
CM 1483	599	799	PC Connection	Sigma Designs							
CM 2087	1,799	3,599	MicroProfessionals	L'View	1,586	2,695	Publishing Perfection				
CM 2087	2,295	3,599	CAD & Graphics	SilverView	1,765	3,695	Publishing Perfection				
IBM				Sony							
8515	699	950	Paradise	CPD 1304	599	1,149	ET Valueline				
NEC				CPD 1304	619	1,149	Microcomputer Concepts				
MultiSync 2A	449.95	799	Lyco Computer	CPD 1304	629	1,149	FastMicro				
MultiSync 2A	499	799	PC Connection	SVGA MONITORS							
MultiSync 2A	545	799	Microwarehouse	Magnavox							
MultiSync 3Ds	585.95	1,099	Lyco Computer	7CM321	329.95	799	Lyco Computers				
MultiSync 3Ds	599	1,099	Laser Press & Graphics	7CM321	334.40	799	Computer Discount Whse.				
MultiSync 3Ds	689	1,099	PC Connection	7CM321	339.95	799	Computer Direct				
MultiSync 4Ds	984.54	1,799	Data Dynamics	Nanao							
MultiSync 4Ds	989.95	1,799	Lyco Computer	9070U	999	1,779	HSI Hotline				
MultiSync 4Ds	999	1,799	Laser Press & Graphics	9070U	1,019	1,779	Bulldog Computer				
MultiSync 5D	2,135.95	3,699	Lyco Computer	9070U	1,095	1,779	CAD & Graphics				
MultiSync 5D	2,200	3,699	Data Dynamics	9080i	1,249	1,999	HSI Hotline				
MultiSync 5D	2,295	3,699	Laser Press & Graphics	9080i	1,269	1,999	Bulldog Computer				
MultiSync 5D	2,295	3,699	Laser Press & Graphics	9080i	1,395	1,999	CAD & Graphics				
MultiSync GS2A	202.95	349	Lyco Computer	VGA MONITORS							
MultiSync GS2A	229	349	Microwarehouse	IBM							
Panasonic				8503	209.95	275	TriState Computer				
C1381	309	699	Electrified Discounters	8503	227	275	Paradise				
C1381	339	699	Bulldog Computer	8512	449.95	675	TriState Computer				
C1381	369	699	Microwarehouse	8512	459	675	Paradise				
C1395	519	1,039	MicroProfessionals	8513	525	750	Paradise				
C1395	549	1,039	Bulldog Computer	8513	529.95	750	TriState Computer				
C1395	599	1,039	Microwarehouse	Zenith							
Sampo				Z 1492	524.17	999	Computer Discount Whse.				
AlphaScan	1,695	2,295	CAD & Graphics	Z 1492	592	999	MidWest Computer Works				
OfficePro II	995	1,595	CAD & Graphics	Z 1492	599	999	FastMicro				
OfficePro IIA	1,395	1,995	CAD & Graphics								
TriSync	1,295	1,895	CAD & Graphics								

For dealer addresses and phone numbers see page 78

SOFTWARE

MANUFACTURER/ PRODUCT	STREET PRICE	LIST PRICE	DEALER	MANUFACTURER/ PRODUCT	STREET PRICE	LIST PRICE	DEALER
UTILITY SOFTWARE							
Abacus				Suitcase II	49	79	ComputerMill
BeckerTools	69	139	Software Add-Ons	Funk Software			
BeckerTools	76	139	MicroWarehouse	Allways 1.2	104	195	Software Unlimited
BeckerTools	79	139	Publishing Perfection	Allways 1.2	109	195	Software Add-Ons
Ashton Tate				Allways 1.2	119	195	Dustin Discount
Control Room	69	129	FastMicro	Sideways 3.2	65	89.95	Dustin Discount
Control Room	69	129	Software Add-Ons	Sideways 3.3	54.99	89.95	America's Most Wanted S/W
Asymetrix				Sideways 3.3	55	89.95	Telemart
Toolbook	279	395	FastMicro	Gazelle			
Toolbook	299	395	Compuclassics	OPtune	42	99.95	Telemart
Atech/M				OPtune	45	99.95	Software Add-Ons
Pub's PowerPak	45	79.95	FastMicro	OPtune	49	99.95	Software Unlimited
Pub's PowerPak	45	79.95	Publishing Perfection	Gibson Research			
Pub's PowerPak	55	79.95	MicroWarehouse	SpinRite II	62.95	89	ComputAbility
Bloc Publishing				SpinRite II	67	89	Compuclassics
PopDrop+	53	99.95	FastMicro	SpinRite II	68	89	ALpc, Inc.
PopDrop+	53	99.95	Software Add-Ons	Helix			
Borland				Headroom 2.0	59	129	FastMicro
ObjectVision	89	99	PC Zone	Headroom 2.0	64	129	PC Zone
ObjectVision	89	99	Star Ware	Headroom 2.0	65	129	Software Unlimited
Central Point				NetRoom			
Copy II PC 6.0	23	39.95	Telemart	NetRoom	49	79	MicroWarehouse
Copy II PC 6.0	24	39.95	PC Zone	NetRoom	50.95	79	ComputAbility
Copy II PC 6.0	25.95	39.95	ComputAbility	NetRoom	52	79	PC Connection
PCTools Deluxe				IBM			
PCTools Deluxe	83	179	Publishing Perfection	Current 1.1	209	395	Software Add-Ons
PCTools Deluxe	109	179	ALpc, Inc.	Current 1.1	209	395	Telemart
PCTools Deluxe	110.99	179	America's Most Wanted S/W	Laser Tools			
Dariana Technologies				PrinCache	98	129	Publishing Perfection
WinSleuth	74.95	149	ComputAbility	PrinCache	99	129	Publisher's Toolbox
WinSleuth	82	149	PC Zone	PrinCache	99.95	129	ComputAbility
WinSleuth	85	149	MicroWarehouse	Trading Post			
Delta Technology				Trading Post	61	79	Publisher's Toolbox
Direct Access 5.0	59	89.95	Telemart	Trading Post	61	79	Publishing Perfection
Direct Access 5.0	60.95	89.95	ComputAbility	LaserGo			
Direct Access 5.0	61.99	89.95	America's Most Wanted S/W	GoScript+	172	299	Software Add-Ons
Fifth Generation				GoScript+	175	299	Telemart
FastBack+ 2.1	107	189.95	Star Ware	Lotus Development			
FastBack+ 2.1	119	189.95	Compuclassics	Magellan	95.85	139	Computer Discount Whse.
FastBack+ 2.1	119	189.95	Dustin Discount	Magellan	115	139	Dustin Discount
Mace 1990				Magee Enterprises			
Mace 1990	82	149	Software Add-Ons	AutoMenu 4.5	35	69.95	Telemart
Mace 1990	85	149	Software Unlimited	AutoMenu 4.5	39	69.95	Compuclassics
Mace 1990	99	149	Dustin Discount	AutoMenu 4.5	45	69.95	Dustin Discount
Mace Vaccine				Merrill & Bryan			
Mace Vaccine	53	99	Software Unlimited	Turbo EMS	52	99.95	Software Add-Ons
Mace Vaccine	57	99	Software Add-Ons	Turbo EMS	55	99.95	PC Zone
Suitcase II	47	79	Publisher's Toolbox	Turbo EMS	56	99.95	MicroWarehouse

For dealer addresses and phone numbers see page 78

STREET PRICE GUIDE: DEALERS

DEALERS

ALpc, Inc. 1762 Westwood Blvd., Ste. 420, Los Angeles, CA 90024, Phone: (800) 955-2572, (213) 446-5521	Data Dynamics PO Box 4129, Blue Jay, CA 92317, Phone: (800) 999-1172, (714) 336-5333	Microwarehouse PO Box 3014, Lakewood, NJ 08701-3014, Phone: (800) 367- 7080, (908) 370-0518	SolidTech 2014 Rt. 22E, Scotch Plains, NJ 07076, Phone: (800) 321-8922
Aberdeen 1125 S. Maple Ave., Unit P, Montebello, CA 90640, Phone: (800) 552-6868, (213) 725-3368	Dustin Discount 20969 Ventura Blvd., Ste. 13, Woodland Hills, CA 91364, Phone: (800) 274-6611, (818) 710-9174	MidWest Computer Works 350 Lexington Dr., Buffalo Grove, IL 60089, Phone: (800) 669-5208	Star Ware 3174 Sunset Ave., Norristown, PA 19403, Phone: (800) 523-0702
Access Computer Tech. 2225 El Camino Real, Santa Clara, CA 95050, Phone: (800) 359-6800, (408) 247-4444	ET ValueLine 7350 N. Linder Ave., Skokie, IL 60077, Phone: (800) 395-1000, (708) 677-7660	MidWest MicroPeripherals 6910 US 66 E., Fletcher, OH 45326, Phone: (800) 423-8215	Storage Devices, Inc. PO Box 58234, Webster, TX 77598, Phone: (800) 835-3023
Advanced Computer Products 1310 E. Edinger, Santa Ana, CA 92705, Phone: 800-FONE-ACP, (800) 366-3227	Electrified Discounters 1066 Sherman Ave., Hamden, CT 06514, Phone: (800) 678-8585, (203) 287-1976	Minuteman Computers 887 19th St., Unit C, Costa Mesa, CA 92627, Phone: (800) 688- 6468, (714) 646-9814	Sunnytech 500 Hollister Rd., Teterboro, NJ 07608, Phone: (800) 367-1132
America's Most Wanted Software 2401 West Bay Dr., Ste. 126, Largo, FL 34640, Phone: (813) 588-1341, (813) 588-1339	FastMicro 3655 E. LaSalle St., Phoenix, AZ 85040, Phone: (800) 821-9000, (602) 437-5700	Miracie Computers 780 Montague Expwy., #202, San Jose, CA 95131, Phone: (800) 969-8177, (408) 435-8177	Swan Technologies 3075 Research Dr., State College, PA 16801, Phone: (800) 468-9044
Arlington Computer 1970 Carboy, Mt. Prospect, IL 60056, Phone: (800) 548-5105, (708) 228-6333	HSI Hotline 131 East Brokaw Rd., San Jose, CA 95112, Phone: (800) 526-2328	PC Connection 6 Mill St., Marlow, NH 03456, Phone: (800) 243-8088, (603) 446- 7721	Syntax 18535 E. Gale Ave., Industry, CA 91748, Phone: (800) 552-8900, (818) 854-6363
Bulldog Computer 610 Industrial Park Dr., Evans, GA 30809, Phone: (800) 438-6039	Hard Drives International 1912 W. 4th St. Dept. HDU, Tempe, AZ 85281, Phone: (800) 767-DISK, (800) 733-0882	PC Zone 18005 NE 68th St., Ste. A110, Redmond, WA 98052, Phone: (800) 252-0286, (206) 883-3088	TSC Computer Products 1819 N. Floradale Ave., S. El Monte, CA 91733, Phone: (818) 579-2405
CAD & Graphics 1301 Evans, San Francisco, CA 94104, Phone: (800) 288-1611, (415) 647-9671	JB Technologies 5105 Maureen La., Moorpark, CA 93021, Phone: (805) 529-0908	Paradise PO Box 890553, Dallas, TX 75389- 0553, Phone: (800) 348-4727	Telemart 8804 N. 23rd Ave., Phoenix, AZ 85021, Phone: (800) 537-4735
California Microchip 9240 Deering Ave., Chatsworth, CA 91311, Phone: (800) PRO- CHIP, (818) 884-3660	Laser Press & Graphics 4888 Stamp Rd., Marlow Heights, MD 20748, Phone: (800) 628- 4517, (301) 899-1118	Publisher's Toolbox 6606 Carlsbad Dr., Madison, WI 53705, Phone: (800) 233-3898	Treasure Chest 1310 Carroll St., Kenner, LA 70062, Phone: (800) 245-3040, (504) 468-2113
Compuclassics PO Box 10598, Canoga Park, CA 91309, Phone: (800) 733-3888	Lucky Computers 1701 Greenville Ave. #602, Richardson, TX 75081, Phone: (800) 966-5825, (214) 690-6110	Publishing Perfection W156 N8327 Pilgrim Rd., Menomonee Falls, WI 53051, Phone: (800) 782-5974, (414) 255- 7600	Tredex 5306 Beethoven Ave., Los Angeles, CA 90066, Phone: (800) 338-0939, (213) 301-0300
ComputAbility PO Box 17882, Milwaukee, WI 53217, Phone: (800) 558-0003, (414) 357-8181	Lyco Computer PO Box 5068, Jersey Shore, PA 17740, Phone: (800) 233-8760, (717) 494-1030	Quick Electronics 10800 76th Ct. N., Largo, FL 34647, Phone: (800) 800-5500, (813) 546-9299	TriState Computer 160 Broadway, New York, NY 10038, Phone: (800) 433-5199, (212) 349-3134
Computer Direct 22292 N. Pepper Rd., Barrington, IL 60010, Phone: (800) BUY- WISE, (708) 382-5108	MegaHaus Drives 1110 NASA Rd., 1, Ste. 306, Houston, TX 77058, Phone: (800) 426-0560, (713) 333-1910	Ralin Wholesalers PO Box 450, Orchard Park, NY 14127, Phone: (800) 752-9512	U \$ave 1702 W. Camelback #376, Phoenix, AZ 85015-3372, Phone: (800) 362-7640
Computer Discount Whse. 2840 Maria, Northbrook, IL 60062, Phone: (800) 726-4CDW	MicroLab 23976 Freeway Park Dr., Farmington Hills, MI 48335, Phone: (800) 677-7900	Siilverado 12010 Hwy. 290 W. #110, Austin, TX 78737, Phone: (800) 284-0764	USA Flex 135 N. Brandon Dr., Glen Ellyn, IL 60139, Phone: (800) USA-FLEX, (800) 872-3539
Computer Products Corp. 1431 S. Cherryvale Rd., Boulder, CO 80303, Phone: (800) 338-4273	MicroProfessionals 19261 Burnham, Ste. 100, Lansing, IL 60438, Phone: (800) 800-8300	Soft Hard Systems 3316 Sheridan Dr., Amherst, NY 14226, Phone: (800) 999-9531, (716) 834-2125	Under-Ware Electronics 7761 W. Kellogg, Wichita, KS 67209, Phone: (800) 442-1408, (316) 721-2600
DC Drives 1110 NASA Rd., 1, Ste. 304, Nassau Bay, TX 77058, Phone: (800) 872-6007, (713) 333-9602	MicroSales 7715 NW 56 St., Miami, FL 33166, Phone: (800) 222-8324, (305) 599- 9470	Software Add-Ons 2 Greenwood Sq., Ste. 155, Bensalem, PA 19020, Phone: (800) 822-8088	Warehouse 54 2415 S. Roosevelt, Tempe, AZ 85282, Phone: (800) 735-0054
Damark 7101 Winnetka Ave., N., Minneapolis, MN 55429-0900, Phone: (800) 729-9000, (800) 788- 7001	Microcomputer Concepts 15200 Transistor La., Huntington Beach, CA 92649, Phone: (800) 772-3914, (714) 898-3002	Software Unlimited 2465 W. 12th St., Ste. 5, Tempe, AZ 85281, Phone: (800) 926- SOFT, (800) 926-7638	

Specifications



PC/XT

Motherboard:

CPU: Intel 8088-2 (typical).

DMA channels: Four DMA channels via an 8237AC-5 DMA controller.

RAM: 640K maximum on motherboard. Typical: 4164 DRAM (dynamic RAM) chips; nine chips per bank; 64K per bank; 41256 DRAM chips; nine chips per bank; 256K per bank.

EPROM/ROM: Two or more 28-pin sockets for 8K x 8, 16K x 8, or 32K x 8 bit EPROM; ROM BIOS chip (2764) in socket (labeled ROM7).

Power-on self-test RAM, I/O ports built in ROM BIOS.

Expansion slots: Eight 62-pin expansion slots.

Bus width: 8 bits.

Address bus: 20 bits.

Interrupts: Eight levels of prioritized interrupts via an 8259A interrupt controller.

Timers: Three timer/counter channels.

Speaker output: Speaker in case.

Size of board: 8 1/2- by 12-inches.

Power Minimum 135 watts, providing +12, -12, +5, and -5 volts. Pin-compatible w/PC/XT power supply.

Keyboard: Five-pin DIN connector, operating power from motherboard; pin and ASCII code compatible with PC/XT keyboard.

AT

Motherboard:

CPU: Intel 80286.

DMA channels: Four DMA channels via an 8237AC-5 DMA controller.

RAM: 1M max on motherboard. Typical: 41256 DRAM chips; 9 chips per bank; 256K/bank, 4 banks.

EPROM/ROM: Two or more 28-pin sockets for 8K x 8, 16K x 8, or 32K x 8 bit EPROM; ROM BIOS chip (2764) in socket (labeled ROM7).

Power-on self-test (RAM, I/O ports) built into ROM BIOS.

Expansion slots: Eight 62-pin expansion slots; typically five

or more extended slots providing additional 40 pins for 16-bit bus.

Bus width: 16 bits.

Address bus: 24 bits.

Interrupts: 15 levels of prioritized interrupts via an 8259A interrupt controller.

Timers: Three timer/counter channels.

Speaker output: Speaker in case.

Size of board: 11 1/2- by 12 3/4-inches.

Power: Minimum 192 watts, providing +12, -12, +5, and -5 volts. Pin-compatible with PC/AT power supply.

Keyboard: 5-pin DIN connector, operating power from motherboard; pin and ASCII code compatible with PC/AT keyboard.

386/486

Motherboard:

CPU: Intel 80386 or 80486.

DMA channels: Four DMA channels via an 8237AC-5 DMA controller.

RAM: 4M maximum on motherboard.

EPROM/ROM: Two or more 28-pin sockets for 8K x 8, 16K x 8, or 32K x 8 bit EPROM; ROM BIOS chip (2764) in socket (labeled ROM7).

Power-on self-test (RAM, I/O ports) built into ROM BIOS.

Expansion slots: Eight 62-pin expansion slots; typically five or more extended slots providing additional 40 pins for 16-bit bus, and 1 slot providing connector for 32-bit bus.

Bus width: 32 bits (one slot may have 32-bit bus to accommodate memory card); 386SX 16 bits.

Address bus: 32 bits (80386SX 24 bits).

Interrupts: 15 levels of prioritized interrupts via an 8259A interrupt controller.

Timers: Three timer/counter channels.

Speaker output: Speaker in case.

Size of board: 11 1/2- by 12 3/4-inches.

Power: Minimum 192 watts, providing +12, -12, +5, and -5 volts. Pin-compatible with PC/AT power supply.



Schematics

XT - Motherboard 1 of 6

Following are schematics for an XT-compatible motherboard and keyboard. Note that the schematics are generic; they may not exactly match your components. They are reproduced here only for your convenience and reference. More than likely, your motherboard will come with a set of schematics that you can use in case of trouble. The motherboard schematics continue six pages; followed by the keyboard schematic.

Schematics

XT - Motherboard 2 of 6



Schematics 2 of 6



Schematics

XT - Motherboard 3 of 6

Schematics 3 of 6

Schematics

XT - Motherboard 4 of 6



Schematics 4 of 6



Schematics

XT - Motherboard 5 of 6

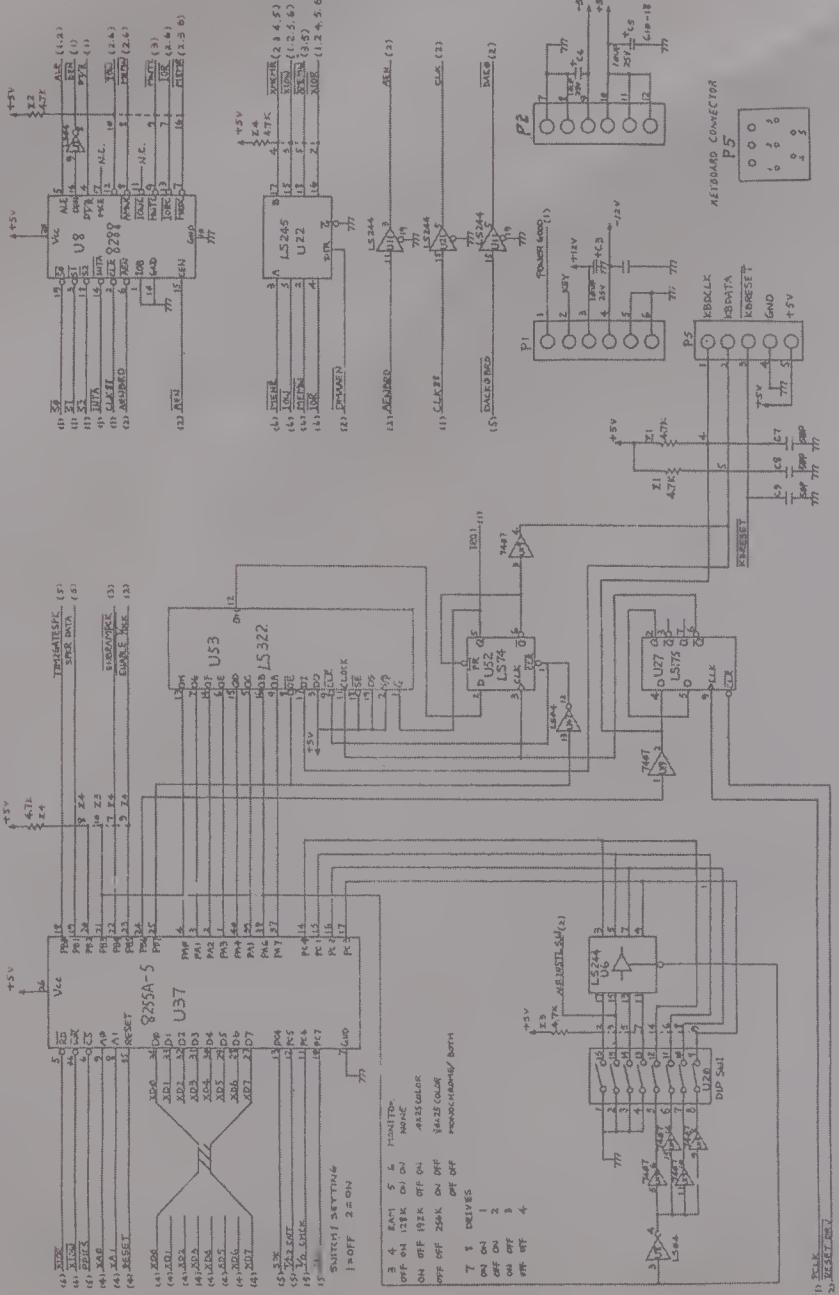
Schematics 5 of 6

Schematics

XT - Motherboard 6 of 6



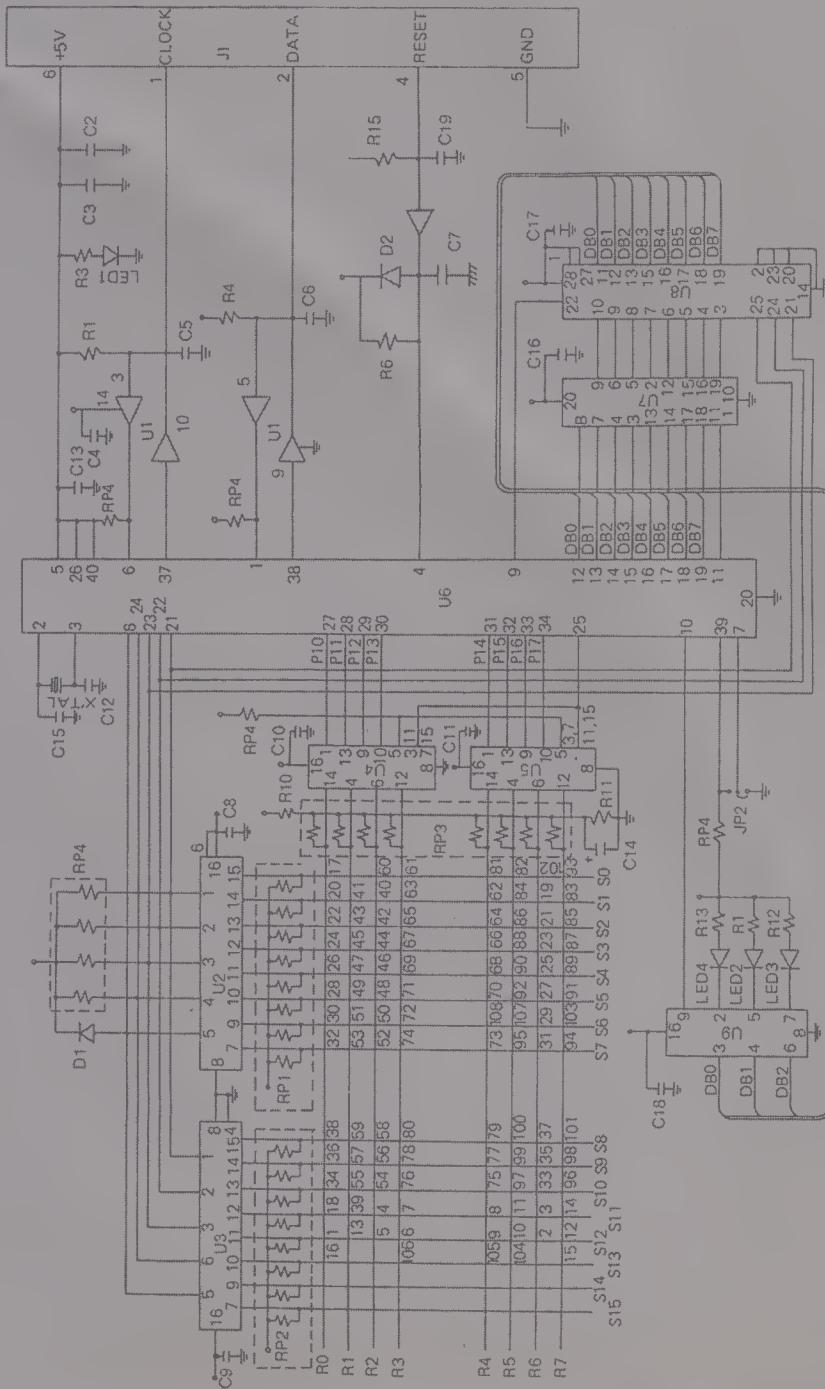
Schematics 6 of 6





Schematics

XT - Keyboard 1 of 1



Connector Pinouts



PINOUTS • IN • THIS • SECTION

- Motherboard Power Supply Connector
- Disk Drive Power Tap
- Speaker Terminal
- LED Power and Key Lock
- Turbo LED Connector
- Battery Connector
- 20286/80386/80486 Motherboard Option Switch
- Expansion Slot 8-Bit Expansion Slot Connector
6-Bit Auxiliary Expansion Connector
- Floppy Disk Drive Signal Cable
- Hard Disk Drive Data and Control Cables
- Keyboard Connector
- Monochrome Display Adapter Pinouts
- Color Graphics Adapter Pinouts
- Enhanced Graphics Adapter Pinouts
- Video Graphics Array Pinouts
- Parallel Printer Port
- Serial Port

- **Motherboard Power Supply Connector**
The power supply connector is located on the upper right corner of the motherboard. Though the connector is one complete unit, in most cases, two separate cables from the power supply connect to the motherboard. Pin 1 is at the top of the connector, nearest the edge of the board.

Cable #1 ("P8")

Pin	Purpose
1	Power-good
2	+5 VDC (or empty)
3	12 VDC
4	-12 VDC
5	Ground
6	Ground

Cable #2 ("P9")

Pin	Purpose
1	Ground
2	Ground
3	-5 VDC
4	+5 VDC
5	+5 VDC
6	+5 VDC

- **Disk Drive Power Tap**

Floppy and hard disk drives derive their power directly from the power supply (exception: hard-disk-drives-on-a-card). Pin 1 is at the very left edge of the connector, when viewing end-on, with the key noted on the top.

Pin	Purpose
1	+12 VDC
2	Ground
3	Ground
4	+5 VDC

CONNECTOR PINOUTS

• Speaker Terminal

The speaker terminal is located along the front left edge of the motherboard, directly beneath the RAM sockets.

Pin	Purpose
1	- Speaker (Q1)
2	Key (blank)
3	Ground (not used)
4	+ Speaker (+5VDC)

• LED Power and Key Lock

Pin	Purpose
1	LED power
2	Ground
3	Ground
4	Key lock
5	Ground

• Turbo LED Connector

1	+5 VDC
2	/FSEL
3	+5 VDC

• Battery Connector

1	Batt +
2	Key
3	Ground
4	Ground

• Motherboard Option Switch

20286/80386/80486

1	Reserved (OFF)
2	80x87 co processor (OFF=not installed)
3	Reserved (OFF)
4	Reserved (OFF)
5	Reserved (OFF)
6	Reserved (OFF)
7	Video adapter (OFF=monochrome)

Motherboard Option Switch Expansion Slot

Most motherboards contain five or eight expansion slots. All are identical and electrically connected to one another on a common bus. In XT class clones, the expansion slots consist of 62 pins in two rows of 31 pins each. Additional pins (housed in separate connectors) are provided in AT-class clones for some (if not all) of the expansion slots.

8-Bit Expansion Slot Selector

Pin	Function	Pin	Function
A1	I/O CK	A2	SD7
A3	SD6	A4	SD5
A5	SD4	A6	SD3
A7	SD2	A8	SD1
A9	SD0	A10	-I/O CH RDY
A11	AEN	A12	SA19
A13	SA18	A14	SA17
A15	SA16	A16	SA15
A17	SA14	A18	SA13
A19	SA12	A20	SA11
A21	SA10	A22	SA9
A23	SA8	A24	SA7

Pin	Function	Pin	Function
A25	SA6	A26	SA5
A27	SA4	A28	SA3
A29	SA2	A30	SA1
A31	SA0		
B1	GND	B2	RESET DRV
B3	+5 VDC	B4	IRQ 9
B5	-5 VDC	B6	DRQ 2
B7	-12 VDC	B8	OWS
B9	+12 VDC	B10	GND
B11	-SMEMW	B12	-SMEMR
B13	-IOW	B14	-IOR
B15	-DACK3	B16	DRQ3
B17	-DACK1	B18	DRQ1
B19	-REFRESH	B20	CLK
B21	IRQ7	B22	IRQ6
B23	IRQ5	B24	IRQ4
B25	IRQ3	B26	-DACK2
B27	T/C	B28	BALE
B29	+5 VDC	B30	OSC
B31	GND		

16-Bit Auxiliary Expansion Connector

C1	SBHE	C2	LA23
C3	LA22	C4	LA21
C5	LA20	C6	LA19
C7	LA18	C8	LA17
C9	-MEMR	C10	-MEMW
C11	SD08	C12	SD09
C13	SD10	C14	SD11
C15	SD12	C16	SD13
C17	SD14	C18	SD15
D1	-MEM CS16	D2	-I/O CS16
D3	IRQ10	D4	IRQ1
D5	IRQ12	D6	IRQ13
D7	IRQ4	D8	-DACK0
D9	DRQ0	D10	-DACK5
D11	DRQ5	D12	-DACK6
D13	DRQ6	D14	-DACK7
D15	DRQ7	D6	+5 VDC
D17	-MASTER	D18	GND

• Disk Drive Signal Cable

The floppy disk drive signal cable carries the signal from the disk drive to the disk drive controller card. The following pinouts are for the signal cable, as connected to the controller card. Land 1 is located nearest the key slot in the controller card edge connector. Note: Odd land numbers 1 through 33 are Ground.

Land	Purpose
1-33 (odd)	Ground
2,4,6	Unused
8	Index
10	Motor Enable A
12	Drive Select B
14	Drive Select A
16	Motor Enable B
18	Direction (stepper)
20	Step pulse
22	Write data
24	Write enable

Land	Purpose
26	Track 0
28	Write protect
30	Read data
32	Select head
34	Unused

• Hard Disk Drive

Both the ST-506 and ESDI hard disk drive controllers use two cables: one for the control signals and one for the data signals. The SCSI hard drive controller uses one cable that combines control and data signals. Following are pinouts for all three kinds of hard disk controller cards.

ST-506 Control Cable

Pin	Purpose	Pin	Purpose
1	Head select 8	2	Ground
3	Head select 4	4	Ground
5	Write gate	6	Ground
7	Seek complete	8	Ground
9	Track 0	10	Ground
11	Write default	12	Ground
13	Head select 1	14	Ground
15	Reserved	16	Ground
17	Head select 2	18	Ground
19	Index	20	Ground
21	Ready	22	Ground
23	Step	24	Ground
25	Drive select 1	26	Ground
27	Drive select 2	28	Ground
29	Drive select 3	30	Ground
31	Drive select 4	32	Ground
33	Direction in	34	Ground

ST-506 Data Cable

1	Drive selected	2	Ground
3	Reserved	4	Ground
5	Reserved	6	Ground
7	Reserved	8	Ground
9	Reserved	10	Reserved
11	Ground	12	Ground
13	MFM write data +	14	MFM write data
15	Ground	16	Ground
17	MFM read data +	18	MFM read data -
19	Ground	20	Ground

ESDI Control Cable

Pin	Purpose	Pin	Purpose
1	Head select 3	2	Ground
2	Head select 2	4	Ground
5	Write gate	6	Ground
7	Config/status data	8	Ground
9	Transfer ack.	10	Ground
11	Attention	12	Ground
13	Head select 0	14	Ground
15	Sec/addr mark fnd	16	Ground
17	Head select 1	18	Ground
19	Index	20	Ground
21	Ready	22	Ground
23	Transfer request	24	Ground
25	Drive select 1	26	Ground
27	Drive select 2	28	Ground
29	Drive select 3	30	Ground
31	Read gate	32	Ground

Pin	Purpose	Pin	Purpose
33	Command data	34	Ground
ESDI Data Cable			

1	Drive selected	2	Sec/addr mark found
3	Seek complete	4	Address mark enable
5	Reserved/step mode	6	Ground
7	Write clock +	8	Write clock -
9	Cartridge changed	10	Read ref clock +
11	Read ref clock -	12	Ground
13	NRZ write data +	14	NRZ write data
15	Ground	16	Ground
17	NRZ read data +	18	NRZ read data -
19	Ground	20	Index

SCSI Cable

1	Ground	2	Data line 0
2	Ground	4	Data line 1
5	Ground	6	Data line 2
7	Ground	8	Data line 3
9	Ground	10	Data line 4
11	Ground	12	Data line 5
13	Ground	14	Data line 6
15	Ground	16	Data line 7
17	Ground	18	Parity line (data)
19	Ground	20	Ground
21	Ground	22	Ground
23	Ground	24	Ground
25	N/C	26	Terminator power
27	Ground	28	Ground
29	Ground	30	Ground
31	Ground	32	Attention
33	Ground	34	Ground
35	Ground	36	Busy
37	Ground	38	Acknowledge
39	Ground	40	Reset
41	Ground	42	Message
43	Ground	44	Select
45	Ground	46	C/D
47	Ground	48	Request
49	Ground	50	I/O

• Keyboard Connector

The keyboard connector is located at the rear of the motherboard, above the microprocessor. The connector is a five pin DIN type.

Pin	Purpose
1	Keyboard clock
2	Keyboard serial data
3	Keyboard select
4	Ground
5	+5VDC

• Monochrome Display Adapter

The monochrome display adapter (MDA) attaches to the computer by way of a DB-9 connector. The pin-outs for the connector are as follows (note that these pin-outs are also used by Hercules monochrome graphics adapters):

Pin	Purpose
1	Ground
2	Ground
3	Not used
4	Not used

CONNECTOR PINOUTS

Pin	Purpose
5	Not used
6	Intensity
7	Video
8	Horizontal drive
9	Vertical drive

• Color Graphic Adapter

The color graphics adapter (CGA) attaches to the computer by way of a DB-9 connector. The pin-outs for the connector are as follows:

Pin	Purpose
1	Ground
2	Ground
3	Red
4	Green
5	Blue
6	Intensity
7	Reserved
8	Horizontal drive
9	Vertical drive

• Enhanced Graphics Adapter Pinout

The enhanced graphics adapter (EGA) attaches to the computer by way of a DB-9 connector. The pin-outs for the connector are as follows:

Pin	Purpose
1	Ground
2	Secondary Red
3	Primary Red
4	Primary Green
5	Primary Blue
6	Secondary Green/Intensity
7	Secondary Blue/Mono Video
8	Horizontal drive
9	Vertical drive

• Video Graphics Array Pinouts

The video graphics array (VGA) attaches to the computer by way of a DB-15 connector. The pin-outs for the connector are as follows:

Pin	Purpose
1	Red video
2	Green video
3	Blue video
4	Monitor ID bit #2
5	Ground
6	Red ground
7	Green ground
8	Blue ground
9	Key (blanked hole)
10	Sync. ground
11	Monitor ID bit #0
12	Monitor ID Bit #1
13	Horizontal sync
14	Vertical sync
15	Not used (reserved)

• Parallel Printer Port

Although the pin-out assignments of parallel ports can differ from one expansion board to the other, the primary signal lines for sending data to a printer and receiving status information back are the same. Here are the standardized pin-outs for the typical parallel port (your parallel port may have additional functions for some pins).

Pin	Purpose
1	Strobe (data is ready)
2	Data bit 0
3	Data bit 1
4	Data bit 2
5	Data bit 3
6	Data bit 4
7	Data bit 5
8	Data bit 6
9	Data bit 7
10	Acknowledge
11	Busy
12	Paper out
13	Select
14	Auto-feed
15	Error
16	Initialize printer
17	Select input
18-25	Ground

• Serial Ports

Serial ports are used to send and receive data bi-directionally. Only three data lines are truly necessary for this task: a ground, a transmit line, and a receive line. Most serial ports provide additional functions. At a minimum most serial ports provide the following. Two serial port connectors are used: one with 25 pins (XT) and one with nine pins (AT).

25-Pin Serial Connector (DB-25)

*Pins not identified are used as ground

Pin	Purpose	Mnemonic
2	Transmit data	TXD
3	Receive data	RXD
4	Request to send	RTS
5	Clear to send	CTS
6	Data set ready	DSR
7	Signal ground	GND
8	Carrier detect	CD
20	Data terminal ready	DTR
22	Ring Indicator	RI

9-Pin Serial Connector (DB-9)

1	Carrier detect	CD
2	Receive data	RXD
3	Transmit data	TXD
4	Data terminal ready	DTR
5	Signal ground	GND
6	Data set ready	DSR
7	Request to send	RTS
8	Clear to send	CTS
9	Ring indicator	RI

Glossary

AC Alternating Current. Electrical power for operating a computer.

access time The time required to get a byte from memory or disk drive or from random access memory. Disk drive access times are typically in milliseconds, or thousandths of a second; RAM access time is in nanoseconds, or billionths of a second.

acoustic coupler Device for connecting computer with a telephone for data transmission over phone lines.

address Number that indicates the location of a byte of information in computer memory.

address bus The electronic circuitry by which memory, microprocessor, expansion cards, and other elements of the computer system are addressed.

alphanumeric A set of all alphabetic and numeric characters.

ampere A unit of electrical current. Also called "amp."

analog signal - A continuous electrical signal representing a condition (such as temperature or the position of game control paddles). Unlike a digital signal, which is discrete and has only two levels, an analog signal can have an infinite number of levels.

applications software Computer programs written to perform actual tasks, such as accounting and payroll. As opposed to computer utilities and disk operating software programs.

arithmetic logic unit Abbreviated ALU. The element in a central processing unit that carries out all arithmetic and logic operations.

artificial intelligence The ability of a machine to imitate certain human activities, such as problem solving, decision making, perception, and independent learning.

ASCII Acronym for American Standard Code for Information Exchange. Used by all personal computers.

ASCII keyboard A keyboard that contains keys for all printable characters, using ASCII code.

assembler A program that converts the computer's memory into binary code for execution. Acts as a compiler for assembly language.

assembly language Machine language codes translated into mnemonic codes that are much faster for programmers to remember.

async For asynchronous. Computer communications where data is transmitted without separate timing signals. Modem and network communications are most often asynchronous.

AUTOEXEC.BAT An optional batch file that the computer



automatically executes upon start up. Instructions included in the AUTOEXEC.BAT file are run whenever the computer is started or reset.

automatic park A system whereby the heads of a hard disk drive return to a safe area after a certain amount of time or when the drive is turned off.

back up A copy of a disk or disk file.

BASIC Acronym for Beginner's All-purpose Symbolic Instruction Code. Programming language for microcomputers developed as a simplified version of FORTRAN. BASIC is not standard, and can vary from computer to computer. The BASIC dialect for IBM PC compatible computers is Microsoft's GW-BASIC.

bank Typically, a row or column of RAM chips on a motherboard or memory board.

batch file A user-written program that directs operation of the computer. Used to automate functions when using the MS-DOS operating system.

baud A measure of the rate at which digital data is transmitted in bits per second, typically ranges from a low of 300 to 19,200 (19.2k baud).

bay A slot of open space reserved for a disk drive (floppy or hard).

bezel A covering or frame for a floppy disk drive.

BIOS Acronym for Basic Input/Output System. Instructions used by the computer to control fundamental operation, including start-up.

binary A numbering system with just two digits: 1 and 0. Computers group these 1s and 0s together to create more complex forms of data.

bit Acronym for Binary Digit. Represents either of two binary states 1 or 0. Bits are usually grouped in sets of eight (called a "byte") for easier manipulation.

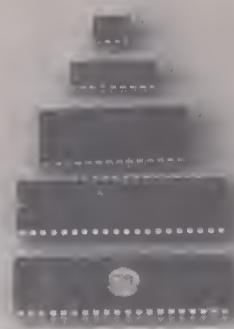
board A printed circuit board that can be plugged into the computer to add new capabilities. Also called a card.

boot A program, on disk or in a permanent portion of the computer's memory (ROM), used to start the computer and get it ready for applications or programming software.

buffer An area of memory used to temporarily hold data being transferred from one device to another, usually from the computer to a printer.

bug An error in a computer program that disrupts normal operation.

bus A set of electrical contacts that carry a variety of com-



puter signals, including those required for memory, operating a modem or printer, and sending data to and from a disk drive. The bus is connected to the microprocessor and support chips, it acts as a connection point for additional circuitry. In the IBM PC and clones, the bus is the set of five or eight expansion slots, used to outfit the computer with additional memory, input/output ports, etc.

bus width See Data Bus Width.

byte A group of bits, usually eight, universally used to represent a character.

cache In computer applications, a temporary holding tank for information. Caches are commonly used to store data used by the microprocessor and hard disk drive. The data can be more rapidly fetched from the cache than from the microprocessor or disk drive.

card A printed circuit board that can be plugged into the computer to add new capabilities. Also called a board.

central processing unit (CPU) 1) Nomenclature for the main microprocessor used inside the computer; 2) The name for the computer system inclusive of the motherboard, power supply, disk drives, and other hardware contained within the primary system "box."

character set The total number of alphanumeric and special and punctuation marks available on a terminal or computer. Some characters may not be normally accessible from the keyboard, but may be so under software control.

chip An integrated circuit, such as that used for computer memory or the microprocessor.

clock 1) Electronic circuit in computer than serves as a timer for the microprocessor, so that all functions are synchronized; 2) The clock/calendar circuit that mains the current time and date.

clock speed The rate at which the microprocessor in a computer operates. The standard clock speed of the XT clones is 4.77 MHz (computers with "turbo" motherboards have an optional clock speed of 8.0 to 12 MHz). AT computers operate at a typical clock speed of 12 MHz; 386- and 486-based computers use clock typical clock speeds of 16 to 33 MHz.

cluster The smallest unit of space on a hard or floppy disk. All hard disks are divided into tracks, sectors, and cluster. Cluster size varies with the capacity of disk and the type of computer used with the drive, but is typically 2K or 4K. The cluster size determines the minimum file size. All files recorded on the hard drive will be recorded in even 2K or 4K

increments.

compiler A program that converts high-level language (like BASIC) into the binary code required by the computer. Compiler instructions are known as "object code." The original high-level language program is known as the "source code."

CONFIG.SYS An optional (but recommended) file containing operating instructions for your computer. The CONFIG.SYS file most often also includes instructions for loading device drivers into memory so that the computer will recognize additional hardware added to it (such as a mouse, high resolution video display, and memory card).

controller A piece of hardware (usually on a separate printed circuit board) that monitors an input/output device. Two common controllers in an IBM PC compatible computer are for operating the disk drives and for connecting the machine to a monitor.

coprocessor An additional microprocessor chip or circuit board that supplements the regular microprocessor in the computer. The 8087 math chip is a common coprocessor for IBM PC compatible computers.

CPS Acronym for characters per second. Usually applies to printer speed, but also sometimes used to indicate the speed of communications, such as when using a telephone modem.

CPU See Central Processing Unit.

crash A failure in hardware or software that interrupts normal operation of the computer, usually resulting in the partial or total loss of data.

CRT Cathode Ray Tube. The most common form of computer display screen.

cylinder The tracks above and below one another (in the same plane) in each disk within a hard or floppy drive. On a two-platter hard disk (with four recording surfaces), the read/write heads will access four tracks at a time. All four tracks constitute one cylinder.

daisywheel printer An impact printer whose printing element resembles a daisy flower. Each "petal" has on the end a character, which strikes against the ribbon and paper to make an impression.

database Systematic organization of data files for easy access, retrieval, and update. A popular type of computer program.

data bus The information path inside the computer. The data bus links the microprocessor, RAM, ROM, disk drives, display adapter, and other components of the computer system.

data bus width The number of paths used to convey data inside the computer. The more pathways, the faster the data can arrive at its destination. The XT uses data paths (referred to as "eight-bit bus"). The AT and 386SX class computers incorporate a 16-bit bus; 386 (DX) and 486 computer use a 32-bit bus.

data encoding Any one of several techniques used to record and later play back data on a floppy or hard disk drive. The encoding technique greatly influences the amount of data that can be stored on the disk, and also partly determines the reliability of the recording. Popular approaches for hard drive data encoding include MFM, RLL, and ARLL.

daughterboard Any circuit board that attaches to the motherboard. Can also mean any auxiliary circuit board that connects to an expansion board, which in turn is fitted into the computer's motherboard.

dbms Data Base Management Software (or System).



default As used in computers, normal, that the standard selection without making changes to available options.

density Amount of data that can be packed into a given amount of space. Usually used to refer to the data capacities of floppy and hard disk drives.

device driver A software program used to enable operation of auxiliary hardware, such as a special monitor or local area network. Most device drivers are loaded into the computer's memory using the CONFIG.SYS or AUTOEXEC.BAT file.

digitizer A device used to convert analog information into digital form. The most common digitizers are used to convert drawing (with a stylus) to direct cursor movement, and video signals into a computerized picture.

DIP Acronym for Dual In-line Package. The typical integrated circuit, consisting of a rectangular housing with connecting pins on both sides. See also SIPP and SIMM.

direct coupled A device for connecting a computer directly with the electronics of a telephone for data transmission over phone lines.

directory A self-contained area on a disk for holding programs and files. You control the directories on your disks so that files are more logically organized. Synonymous with sub-directory. See Root Directory.

disk The flat, circular magnetic storage medium used to record and play back digital data with a computer.

diskette A term often used to denote a "floppy" magnetic disk, rather than the rigid disk platters used in hard disk systems.

DMA Acronym for Direct Memory Access, a techniques used in all PC clones for transferring data between microprocessor and RAM.

DOS Acronym for Disk Operating System. Pronounced "doss" (rhymes with "toss"). Tells the computer how to communicate and interact with the hardware equipment (peripherals) connected to it. The most common DOS used on PC clones is Microsoft's MS-DOS, although the computers can accept a variety of other disk operating systems, including CP/M-86, UCSD p-System, and Xenix.

dot matrix A means by which printed characters are formed using a matrix of small, closely spaced dots. The matrix is fixed and defined as so many dots wide by so many dots high. Typical matrices for dot matrix printers is 5x7, 7x9, 7x12, and so on.

double-density A technique used to double the amount of data that can be stored on one or both sides of magnetic medium. Disk drives sold today for PC compatible computers are double-density.

DRAM Dynamic Random Access Memory, the typical form of memory chips used in personal computers. The other "form" of RAM is "static," or SRAM.

drive A disk drive, either floppy or hard (can also refer to a streaming tape drive, used for backing up large amounts of data from a hard disk).

driver See Device Driver.

dual intensity The ability of a terminal or computer display screen to produce characters in regular as well as bold (extra bright).

editor A computer program used to permit entry of text into a computer system; also a rudimentary word processor program.

EMS Short for Expanded Memory Specification. See Expanded memory.

EPROM Acronym for Erasable Programmable Read-Only

Memory. A type of semi-permanent memory device that can store information indefinitely until specifically rewritten. Often used to contain the BIOS instructions of a PC. See also PROM.

error message Ooops! Something's wrong, and the computer is trying to tell you. With the PC, and especially MS-DOS, error messages are often cryptic, requiring that you refer to a technical manual for instructions on how to proceed.

ESDI Enhanced Small Device Interface, an interface standard developed by manufacturers for connecting a hard disk to a computer.

extended memory Memory used in many AT-class computers to provide more memory beyond the base 640K, and is often used for such tasks as RAM disks. See also expanded memory.

extended partition Extra space on a hard disk, reserved by the operating system, and often appearing as a separate drive (i.e., one physical hard drive, two or more logical drives). Only available with DOS 3.3 or later.

external memory Term usually used for permanent information storage devices, such as hard and floppy disk drives.

expanded memory Additional RAM added to provide more working space for applications programs. Originally developed by a consortium headed by Microsoft, Intel, and Lotus. Can be used on most any PC compatible computer, and within the limits of the microprocessor, provide up to 16 megabytes of RAM. See also extended.

FAT Acronym for File Allocation Table, a critical portion of all hard and floppy disk drives that records the exact placement of files on the media surface.

file A block of information designated by name and considered a complete unit by the computer and user.

file allocation table See FAT.

file attribute Special information about a file contained in the directory of the disk. Among the file attribute information is the date the file was created or last modified and whether the file has been recently archived (backed up).

fixed disk A hard disk, particularly a hard disk with non-removable data (some hard drives provide for removing the media and replacing it with a fresh disk).

floppy disk A magnetic medium used for mass storage of data. Flexible disks are available in 5 1/4- and 3 1/2-inch formats. The term is used to describe the magnetic disk medium itself and its protective jacket. See also Hard Disk.

form factor The physical dimensions of a piece of hardware, such as a computer case, motherboard, or disk drive. The similar form factor of component hardware in PC clones allows you to more easily build your own.

format The organization of data in a file or on a disk. Also the preparation of a disk into tracks so it can accept data.

formatted capacity Most often used in reference to a hard disk, the actual capacity of the disk after formatting. Formatting marks off the surface of hard drive so it can hold data, which wastes a certain amount of real estate on the disk.

FORTRAN Acronym for FORmula TRANslator, a high-level programming language developed for mathematical

GLOSSARY



walkie-talkie is an example of a half duplex device.

hard copy Output from a computer that has been printed on paper.

hard disk A mass storage magnetic medium that uses a rigid platter for storing data. The hard disk media is usually non-removable, so the term hard disk refers to the disk platter and the drive.

hardware Describes all the items in a computer system that are made of electrical components, such as integrated circuits. See also Software.

head That part of a floppy or hard disk drive that records data on the magnetic surface of the disk, then reads it back again. Most floppy and hard disk drives have two or more heads, one head for each recording surface. Because the heads in a disk drive are used to both record and play back computer data, they are often referred to as "read/write heads."

head crash An instance where the magnetic heads of a hard disk drive come into contact with the surface of the media. While somewhat rare in today's hard drives, a head crash almost always means the loss of some data.

head gap The distance between the read/write head and the surface of the disk platter when the hard drive is in use. A cushion of air keeps the head floating above the surface of the drive, thereby reducing friction and wear.

hertz Technical term for relating the frequency of a signal, synonymous with cycles per second. One cycle per second equals one hertz (often abbreviated Hz).

hexadecimal A counting system based on 16 numerals. In computers, hexadecimal counting (or "hex" for short) uses the numerals 0 through 9, plus letters A through F.

high resolution A term used to describe the ability of a video terminal, monitor, or printer to display text and/or graphics in fine detail.

high-level language A programming language that uses English-like words, to make it easier for the user to communicate with the computer. Example high-level languages are BASIC, FORTRAN, and COBOL.

I/O Short for Input/Output. Refers to the paths by which information enters a computer system (input) and leaves the system (output).

index hole A hole punched in the disk that serves as a start point for the disk drive.

interface An electronic or software device used to mate a computer and its peripherals with the outside world.

interleave The relationship between the rate at which a hard disk spins and the organization of the sectors recorded in each track of the disk. Hard drives typically have interleave ratios (or "factors") of 1:1, 2:1, or 3:1. An interleave of 1:1 is ideal.

interrupt In a computer, suspending a primary operating to allow an external device (such as a keyboard, communications

operations required by scientists and engineers.

full duplex A communications mode in which data can be transmitted and received simultaneously. The telephone is an example of a full duplex device.

half duplex A communications mode in which data can be transmitted and received, but not at the same time. The

port, or mouse) to transmit data. PC clones use a complex web of interrupts, some of which can be set by the user.

jumper To electrically connect two contacts together. Often used to select an option on a circuit board, such as a motherboard or expansion board. The jumper consists of two parts: the contact pins, and the jumper block. By removing the block, you "open" the contacts. By installing the block, you "short" the contacts.

keyboard The typewriter-like device used to communicate with the computer.

keypad The calculator-style of numeric and arithmetic keys on most computer keyboards.

kilobyte Term used to denote "1,000" bytes, or 1K (precisely, 1,024 bytes).

kilohertz A unit of electrical frequency equal to one thousand cycles per second; abbreviated kHz.

laser In general personal computer use, a form of printer that uses a laser to print text and graphics on plain paper.

latency In a hard or floppy disk drive, the time it takes for the magnetic heads to read the desired data once the heads have been positioned over the proper track.

logical drive A disk drive (generally a hard drive) which occupies space in the computer's mind, but may not physically exist as a separate component. A single hard drive mechanism can be divided into one or more logical drives, for example drives C: and D:. To the computer the drives are distinct, but they both use the same recording surfaces, read/write heads, controller, and so forth.

LPM Acronym for lines per minute, a specification given to fast, high-out printers.

load The transfer of data from disk to memory.

math co-processor An auxiliary microprocessor installed on the motherboard of a computer to aid in number-intensive calculations. Math co-processors are ideally suited for applications that deal with high precision numbers, such as those containing 32 or 64 digits.

megabyte A term used to indicate millions of bytes; 1 megabyte (1Mb) - 1,048,567 bytes.

megahertz A unit of electrical frequency equal to one million cycles per second; abbreviated MHz.

memory Electronic storage of information, usually in the form of memory chips. There are several types of electronic memory; see EPROM, ROM, and RAM.

MFM An acronym for modified frequency modulation recording, the recording technique used by most hard disk drives.

microsecond One millionth of a second.

microprocessor The brain of the computer. Performs all of the mathematical and logical operations necessary for the functioning of a computer system. Sometimes called the CPU.

millisecond One thousandth of a second.

MIPS Acronym, Millions of Instructions per Second, a way of gauging the capabilities of a microprocessor and computer.

MS-DOS The most popular operating system for PC compatibles. MS-DOS operates on all PC clones, and has been periodically updated since its introduction in 1981 (the IBM brand form of MS-DOS goes by the name PC-DOS, with only minor differences between the two). See also OS/2 and Unix.

modem short for MODulator/DEModulator; a device used to translate the computer's electrical signals to audible tones, for transmission of data through the telephone lines.

module In a computer, any self-contained collection of elec-

tronic circuits. Often used to refer to a pack of RAM chips, soldered onto a convenient user-replaceable circuit board.

motherboard The main printed circuit board in the computer, containing the microprocessor, memory, and support electronics.

MTBF Acronym for Mean Time Between Failure, a statistically derived measure of the typical life expectancy of a piece of hardware. Most often applied to hard disk drives.

multi-user system A type of computer that is engineered to support more than one user concurrently.

network A group of computers and peripherals interconnected, and able to share data and resources. If the group is within close proximity, and attached directly by cable, the interconnection is said to be a Local Area Network, or LAN.

nibble One half a byte, or in PCs, four bytes. Also spelled nybble.

ns Short for nanoseconds, or billionths of a seconds.

number crunching The computer's ability to perform quick mathematical computations. The term is used to mean an application (such as electronic spreadsheets, like Lotus 1-2-3 and Multiplan) or the performance rating of a particular computer.

on-line A phrase used to indicate any device directly connected to a computer; also, the connection of two or more computers via phone lines or other electronic means.

operating system A program or collection of programs used to manage the hardware and logical functions of a computer system.

OS/2 An alternative operating system (to MS-DOS) for PC compatibles, AT class and higher.

parallel A type of input/output scheme where data is transferred eight (or more) bits at a time.

park A process whereby the read/write heads of a hard disk drive are placed in a "safe" area on the surface of the disk so that if the heads contact the disk, little or no important data will be lost.

partition Separate formatted segments of a hard disk drive.

partitioning Setting aside physical portions of a hard disk use in logical drives (see entry), or for storing data under different operating systems. All hard drives have at least one partition, which is the main partition all files are stored in.

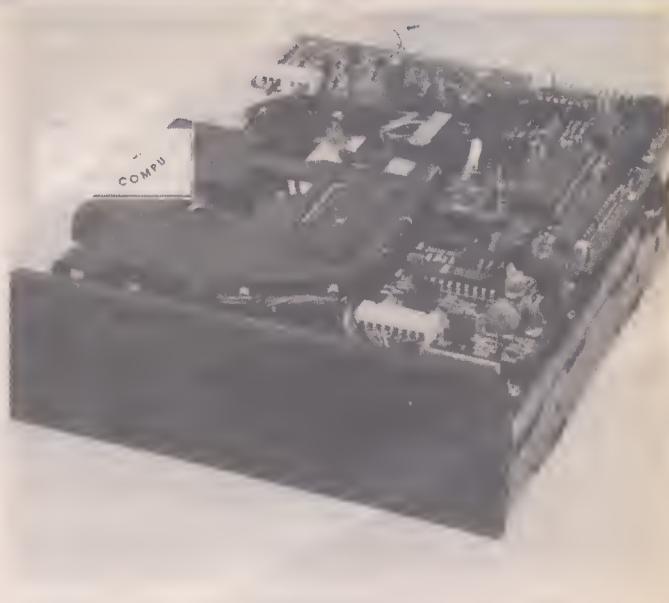
peripheral Any device not necessary for the basic operations of a computer that attaches to it by means of a cable or interface. Printers, modems, and plotters are examples of peripherals.

physical drive A floppy or hard disk drive that exists as a separate piece of hardware. Distinct from a logical drive (see entry) where one hard drive can be segmented into many smaller drives. These smaller drives appear as separate hard disks to your computer, even though they are contained in the same drive case.

pixel Short for picture element. The smallest component on the video screen. Pixels are tiny dots of light that together form an image of a character or picture on the screen.

platter The actual recording disk in a hard disk drive. Most hard drives incorporate two or more platters. Additional platters allow the drive to store more data.

POST Short for Power-On System Test, an automatic test run by the computer each time it is powered on. If a defect is detected, the computer displays an error message on the display, and/or sounds a one or more tones through the speaker. The sequencing of tones can be used to determine the exact



fault, although the sequence used can differ from one make of BIOS to another.

port Another term for interface. Usually refers to parallel and serial interfaces, used to connect devices such as printers and modems to a computer.

power supply PC clones, a self-contained module that supplies regulated voltage to the components of the computer.

PPM Acronym for Pages per Minute, specification usually given to those kinds of printers (such as laser printers) that print all the characters on a page almost instantaneously.

printer A device used to make paper copies of documents and other data.

program Instructions, in a form readable by the microprocessor, that tells the computer what to do. Programs (also called software) can be written in machine language, assemble language, or one of the high-level languages like BASIC and Pascal.

PROM Programmable Read-Only Memory. A type of memory chip that is pre-programmed with data, sometimes used to contain the BIOS instructions of a PC. Once programmed, it cannot be re-programmed. See also EPROM.

quad-density A technique used to quadruple the amount of data that can be stored on one or both sides of magnetic medium. Quad-density floppy drives are sometimes used with PC compatible computers.

rails Metal or plastic guides for installing the motherboard, expansion boards, floppy disk drives, and/or hard disk drives.

RAM Acronym for Random Access Memory. Also called "user" or "program" memory. A type of temporary memory used for storing data, either entered by the user or loaded from the software. RAM is volatile: its contents are lost when the power is removed. See also ROM.

random access Addressable memory; i.e., memory that can be accessed at any point using a numeric address (much like mail can be addressed to a specific house in the city).

resolution Refers to the number of scanning lines on a video display, the number of picture elements on the display used to produce an image, or the sharpness of characters and graphics produced by a matrix printer.

RGB Stands for red-green-blue, the three primary colors used to reproduce a full-color image on a video screen.



ROM Acronym for Read Only Memory. A type of permanent memory where program instruction can be stored, and accessed any time. Unlike RAM, ROM is not volatile; the contents of ROM are not lost when the power is used. In PC compatible computers, the ROM holds the BIOS, the Basic Input/Output System used to make the machine work. See also RAM.

root directory The main directory area of all disks (floppy and hard). All directories you create on a disk branch from this root directory (such supplemental directories are often called subdirectories).

RS-232 A standard set for serial interfaces.

save The act of recording the contents of RAM onto a disk for later retrieval.

SCSI An acronym for Small Computer System Interface, the interface used with many controllers to connect to a hard disk drive.

sector A section of a track on a magnetic disk.

seek time The average time for the read/write heads to move from one track to another track.

serial A type of input/output scheme where data is transferred one bit at a time.

servo positioning A system found in some hard disk drives (particularly the removable mass storage type) whereby special signals previously recorded on the disk aid in accurately positioning the drives for read and write operations.

settling time In a hard or floppy disk drive, the time required for the magnetic heads to achieve equilibrium so that they can effectively read or write data.

SIMM Acronym for Single In-line Memory Module, a type of RAM pack where the RAM chips are soldered into a small user-replaceable circuit board. Metal contacts on the edge of the board facilitate electrical connection to the computer.

SIPP Acronym for Single In-line Pin Package, a type of integrated circuit containing a single row of contact pins.

ST-506 The original hard disk interface standard, still in use today, and employed by the majority of hard drives.

stepping motor A type of motor that moves in discrete steps instead of complete revolutions. Often used in floppy drives, but only occasionally used in modern hard disk drives.

software A program, contained on a disk or within a ROM chip.

SRAM Static Random Access Memory, a special type of RAM chip used in certain portions of some computer systems. Static RAM does not require the support circuitry needed by

RLL An acronym for run-length limited recording, an enhanced recording technique that packs 25 to 50 percent more information on the same size disks than the older MFM technique. The ARLL (advanced run-length limited) recording method packs up to 75 percent more data into a given hard disk.

conventional dynamic RAM, and is generally much faster. However, its design makes it more expensive. A relatively small amount of static RAM (32K to 64K) is often used as a cache for the microprocessor, while dynamic RAM is used for holding data and programs.

storage Generally refers to data and program storage on floppy or hard disks.

throughput The actual amount of data, expressed in megabits or megahertz, transferred between the hard drive, controller, and computer.

track A collection of sectors spaced in a concentric pattern on the surface of the disk. Tracks are divided into sectors, which are further divided into clusters.

track-to-track seek (or access) The time it takes for the read/write heads to move between adjacent tracks.

transfer rate The maximum amount of information, usually expressed in megabits or megahertz, that is passed between hard drive and computer in one second.

TSR Acronym for terminal and stay-resident, a kind of software that loads into memory then stays there, even when you run other programs. Then, by pressing a special sequence of keys ("hot keys") the TSR program is reactivated, and temporarily takes precedence over your computer.

turbo A mode in some PC compatible computers where the microprocessor speeds up, usually top 6.0 MHz.

Unix An alternative operating system for PC compatible computers. Unix is best known for its ability to support more than one user on one main microprocessor.

utility program A type of computer software that is designed to test or enhance the operation of computer or applications software.

virtual memory A technique whereby a microprocessor can borrow disk space on a hard drive and use it as temporary RAM storage. Virtual memory is restricted by the operating system and the microprocessor.

virus In computer parlance, any of several types of programs written to disrupt your computer. Virus programs are most often introduced to your computer unwittingly. Most all computer viruses can be detected and eradicated with the proper utility programs.

voice coil An coil and magnet apparatus used in hard drives to accurately position the read/write heads over the surface of the disk.

volatile memory Memory that will lose its contents if power is removed.

volume Another term for a logical disk (a floppy disk, or a partition in a hard disk). The volume name is the optional name given to that logical disk.

Winchester A type of hard disk drive, now used generically. The name is from IBM, who used "Winchester" as a code for the new type of memory storage device they were developing.

write protect A foil flap or a plastic tab used to prevent accidental erasure of data on a floppy disk. When the flap or tab is in place, the floppy drive cannot physically write new data on the drive, or erase the existing data.



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